INSTITUTES

OF

PHYSICS.

VOLUME FIRST.

> NON FINGENDUM AUT EXCOGITANDUM, SED INVENIENDUM, QUID NATURA FACIAT AUT FERAT.
> BACON.

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PREFACE.

THE following Inſtitutes of Phyſics contain only the General Heads of an annual Courſe of Lectures in the Univerſity of Glaſgow, together with concluſions which reſult from Experiments performed at the ſame time.

In this manner it ſeems proper to guard againſt the inaccuracies into which young ſtudents are apt to fall; while the publication of more than ſuch Outlines might lead them to lay aſide the cuſtom of taking notes: a cuſtom by which their attention and ingenuity is conſtantly exerciſed; and the experiments and lectures become, as it were, their own.

The concluſions from the experiments are expreſſed in the ſynthetic form of propoſitions and corollaries; ſo that every propoſition is like an enunciation in Euclid, and the experiments are exhibited as the proof.

Some of the propoſitions, however, are ſo univerſally admitted, as to render an experimental proof unneceſſary. And ſome of the experiments cannot be made at a public lecture; in which caſe the evidence for their truth, the neceſſary apparatus, and the method of uſing it, are minutely deſcribed; and nothing more can be done.

As technical terms ſave the trouble of repeating definitions, they are to be found not only in every ſcience, but in the loweſt mechanic arts. In Natural Philoſophy they are not many, and their meaning is generally known; but there is an inaccuracy in the great diviſions of this ſcience, which occaſions the following remarks.

In the ſyſtems that are commonly uſed, matter and its general properties are firſt conſidered; and then, the attraction of coheſion, magnetiſm, electricity, and gravitation. Under magnetiſm, the attraction and repulſion of the magnet is explained: under electricity, the repulſive as well as the attractive phenomena of electric matter: and under gravitation, both centripetal and centrifugal forces. But there is no term to denote that branch of Phyſics under which the general properties of matter are conſidered, together with the attraction and repulſion of its minute parts. Atomology, tho an ancient word, would be improper; becauſe of the ideas that are conveyed by it, and becauſe of the doctrines that were maintained by the atomical ſect.

Almoſt all the terms of art in Phyſics are borrowed from the Greeks. Somation, among them, had the ſame meaning with Corpuſcle among us. It, therefore, is uſed for the firſt diviſion of Phyſics, with the addition of Logia, in the manner in which that Greek word is uſually compounded in our language. Thus we are freed from the ſoleciſm of conſidering corpuſcular repulſion as belonging to the attraction of coheſion; and from the abſurdity of having a technical term for every part of Phyſics excepting the firſt.

Matter being the object of Phyſics, after a general explication of its nature is given, the next inquiry is, whether all bodies, or maſſes of matter, have the ſame qualities belonging to them. The ſlighteſt obſervation ſhews that they have not; and it becomes neceſſary to arrange them, if we would know them with certainty and eaſe. Accordingly, they are reduced to ſeven claſſes, and without the detail which Chemiſtry requires.

Thus, it is not only proper to uſe the word Somatiology, but alſo to comprehend under it the general arrangement of bodies, corpuſcular attraction and repulſion, fire, and other corpuſcular phenomena; becauſe if they are not explained, it is impoſſible to underſtand ſome of the moſt common reaſonings, and common inſtruments, which belong to the undoubted branches of Natural Philoſophy in the moſt reſtricted ſenſe.

The claſſes, orders, diviſions, and ſubdiviſions of matter are not a few; but it would ſeem that they cannot be reduced to a ſmaller number without giving up preciſion in arrangement, or aſcribing qualities to bodies which our preſent experiments do not ſupport. Short characters are given not only of the claſſes, but of the diviſions, and of ſome of the genera. The moſt remarkable component parts of the reſt are printed in a different character, upon the right and left hand ſide of the names. And in this arrangement bodies of every kind are claſſed without regard to their external forms, or to the different kingdoms of nature to which they belong.

After Somatiology, the next general diviſions of Phyſics are, Electricity and Magnetiſm. The etymology and objects of both are well known. But ſome diſtinguiſhed writers employ the firſt in an improper ſenſe; for they denote by it not only the name of the ſcience, but alſo the cauſe which produces the effects. In the firſt ſenſe alone it ought to be uſed: for to give the ſame name to things that are different, can never be juſtified; unleſs it is the deſign of the writer to be miſunderſtood. It would be well if this were the only term in philoſophy to which this remark might be applied.

The power of gravity near the ſurface of the earth is the ſubject of the fourth part. Whether it extends to remote diſtances, cannot be examined till the laws of central forces are known, which is a part of Mechanics; and till the laws of the heavenly bodies are known, which is the object of Aſtronomy.

It has been thought by ſome, that an attractive and repulſive power, or even an attractive power differently modified, may produce all the phenomena which are enumerated in theſe four parts of Phyſics. But this is ſuppoſed, not proved; and, therefore, ſince the phenomena are different, theſe four diviſions ought to be preſerved.

Beſides the properties of matter, which are examined in theſe four diviſions, there are others of a very different kind, that are the objects of the fifth. Equivalent terms to foſſils, vegetables, and animals are to be found in every language; and as

Civil Hiſtory is employed in explaining the nature of political bodies, and their various changes; ſo Natural Hiſtory is employed in explaining the nature of mineral, vegetable, and animal bodies, and the changes to which they are ſubject by the laws of nature, in oppoſition to the operations of art.

That all bodies are compoſed of a few kinds of principles or elementary particles, is one of the moſt ancient doctrines in philoſophy; and yet it is only of late that attempts have been made to arrange foſſils according to the elements which they contain. The common method has been to claſs them according to their uſes or external appearances: a method inaccurate and tedious; becauſe uſes are variable, and a multitude of external marks is neceſſary to diſtinguiſh the greateſt part; while ſome have the ſame properties with different appearances, and others the ſame appearances with different properties.

In the ſecond volume they are claſſed according to the genera in the firſt; and the ſpecies are added under each genus, according to their denſities, colours, or hardneſs. This Method is ſimple and fixed, provided the degree of fire is aſcertained; while others not founded upon it have been varied, and may be varied without end. It muſt be remembered, however, that there are but few foſſils which are not compounds; and, conſequently, that they may be placed in this or that claſs, according to the parts of which they are compoſed. To repeat them in every claſs to which ſome of their conſtituent parts belong, would be a troubleſome and uſeleſs taſk; but ſuch as are very heterogeneous, are ſometimes repeated without a number; which will ſhew that they are claſſed in a more natural place.

In order to remove the objections of a very eminent author, it may be proper to obſerve, that the Saxa and Mineralia Larvata cannot be excluded from a ſcientific arrangement: for, what ſhould we think of a ſyſtem, in any other branch of knowledge, which required an appendix? Would not the very name declare, that the ſyſtem was imperfect? Tho Scoriae, therefore, are bodies, which are in a different ſtate from what they once were; tho wood and ſome moulds belong to the vegetable; and ſhells, animals, and lythophyta to the animal kingdom; yet the changes they have undergone were not produced by art: and, therefore, they are foſſils in the juſteſt ſenſe. In courteſy, however, to common Methods, a liſt is given of the moſt noted of the figured ſtones. To enumerate them all would be as difficult, and as uſeleſs, as to arrange the clouds.

Such is the plan of Mineralogy contained in the ſecond volume. It may, perhaps, be well received; as it takes in all Methods to a certain degree; is ſimple; and has this conveniency, that by looking at the general arrangement, it is eaſy to ſee what bodies are produced by nature, and what bodies are produced by art.

It belongs not to the author's province to examine the vegetable kingdom. One may underſtand the nature of a political conſtitution, without knowing the names of the people of whom it conſiſts.

Sexual differences, and fixed external marks render it much more eaſy to claſs the ſecond and third, than the firſt of the kingdoms of nature. Even an improvement will not always juſtify a great change in a Method that is generally received, and eaſily underſtood.

Some Zoologiſts content themſelves with diffuſe and indeterminate deſcriptions; ſo that their Methods are as little ſcientific as that of the Mineralogiſts above mentioned. Others imagine, that all claſſing is as arbitrary as the whimſical arrangement which any one may give to the particles in a heap of ſand. They conſider not, that the time of geſtation, or the progeny's being mules, fix the genera with as much certainty as the elementary particles do in Mineralogy; and that when theſe characters cannot be got, Anatomy furniſhes others which are equally diſtinct. A third ſort aim little at ſcientific marks; but change arrangements in order to make them more elegant or more natural in their opinion. They obſerve not, that all who do ſo in any of the three kingdoms of nature, ought to be viewed in the ſame light with that librarian, who boaſted of having done great ſervice to learning, becauſe he had changed the ſhelves and places of his books.

By the numbers in Mineralogy and Zoology, all the ſpecimens in the phyſical apparatus-room may be eaſily found; and it is proper to obſerve, that, in order to ſave printing, when a ſpecies has the ſame name with its genus, communis or vulgaris is underſtood; and that in many caſes the adjective is only added to the number.

It is often difficult, and ſometimes impoſſible, to find Engliſh words which correſpond exactly with the Greek and Latin terms. It is uſeful for a ſtudent to be made acquainted with ſuch as are to be found in ſtandard authors; and a variety of them is ſometimes uſed for that very purpoſe.

Theſe reaſons, it is hoped, will be a good apology for mixing together the terms of different languages, of common life, and of philoſophy. Some writers ſeem to be as fond of making new names, as if they deſerved praiſe for increaſing the diſagreeable part of ſcience; and as if there was ſome merit in giving different arrangements to letters and ſounds. So much care has been taken to avoid this practice, that there are but two new words in theſe volumes. They were unavoidable, and their meaning is obvious.

Mechanics, Hydroſtatics, Pneumatics, Optics, and Aſtronomy, are the ſubject of the third volume.

Different authors comprehend different things under Mechanics. Some make gravitation belong to it; and others, Hydroſtatics, Pneumatics, and part of Aſtronomy. In this volume it is reſtricted to the laws of ſolids, when acting with different coheſions, velocities, and forms.

Under Hydroſtatics, the Ancients conſidered the laws of water at reſt; and under Hydraulics, the laws of water in motion. The Moderns include both under this term; which is likewiſe done in this volume, but the ancient diſtinction is marked out by a ſubdiviſion in the general arrangement.

The object of Pneumatics is that elaſtic fluid which ſurrounds the earth, and which is neceſſary to preſerve animal life, and vegetable life, and flame; but as part of it is conſtantly loſing this remarkable quality, it becomes neceſſary to conſider how this loſs is effected, and how it is reſtored. Pneumatics, accordingly, is divided into two parts, of common air and factitious air; a term uſed by the philoſophers of the laſt century inſtead of the preſent one, Fixed Air; which is almoſt as improper as a Solid Fluid.

Optics and Aſtronomy make the two laſt diviſions in this ſyſtem. Light and viſion are univerſally made the object of the firſt; and that of the ſecond is ſufficiently known by the etymology of the word, and by what has been already ſaid under Gravitation and Mechanics.

IT was thought proper to make the above obſervations for the ſake of ſuch as may happen to look into theſe volumes, without having ſeen the experiments, or heard the lectures, by which they are explained. And for the ſame reaſon it may be proper to add, that the mathematical parts of Natural Philoſophy, with the hiſtory and tenets of the different ſects, both ancient and modern, are taught by the Author at a ſeparate Lecture, and ſo as to refer to the Experimental Courſe.

INTRODUCTION.

OF PHYSICS.

THE inducements to purſue this branch of philoſophy;

From curioſity, from the love of beauty, truth, and grandeur;

From the advantages it brings to human life, by the improvement of arts, machines, and manufactures;

And from the manifold proofs it gives of wiſdom, power, and goodneſs in the creation.

Of the axioms and poſtulates in Phyſics.

Of the proper method of making experiments; and of the concluſions to be drawn from them, commonly called, the rules of philoſophiſing.

Of the principal perſons who have improved this uſeful ſcience.

Of the parts into which it is divided; and an explanation of the following arrangement.

I. SOMATIOLOGY.

II. ELECTRICITY.

III. MAGNETISM.

IV. GRAVITATION.

V. NATURAL HISTORY.
  - MINERALOGY.
  - BOTANY.
  - ZOOLOGY

VI. MECHANICS.

VII. HYDROSTATICS.
  - HYDROSTATICS.
  - HYDRAULICS.

VIII. PNEUMATICS.

IX. OPTICS.
  - CATOPTRICS.
  - DIOPTRICS.
  - CATADIOPTRICS.

X. ASTRONOMY.

INSTITUTES

OF

PHYSICS.

PART I.

SOMATIOLOGY.

SECT. I.

OF SPACE AND TIME.

Space and Time are ſimple ideas. They are boundleſs, everlaſting, and capable of being divided by the mind without end. They are diſtinguiſhed into abſolute and relative.

Tho we know not enough of ſpace and time to gratify our curioſity, yet what we do know is ſufficient for the happineſs of life.

SECT. II.

OF MATTER AND MOTION.

Matter is extended, moveable, ſolid, and inert.

Motion is a continued change of ſpace. It is abſolute or relative.

Matter may be abſolutely in motion, and relatively at reſt; and on the contrary.

SECT. III.

OF SPACE VOID OF MATTER.

PROP. I.

The denſeſt bodies, or maſſes of matter, are full of pores.

PROP. II.

There are bodies of the ſame bulk, and of unequal weights.

PROP. III.

If bodies of the ſame bulk and unequal weights are let fall in the air, the lighteſt will be ſenſibly retarded; but in a place where there is no air, all bodies, however differing in weight, bulk, or ſhape, fall from the ſame heights with equal velocities.

Proofs from theſe experiments, that all ſpace is not replete with matter.

Of other proofs of a vacuum.

SECT. IV.

OF THE IDEAL DIVISIBILITY OF MATTER.

PROP. I.

Every piece of matter, like every part of ſpace, may be divided by the mind into a number of parts greater than any that can be aſſigned.

The difficulties of conceiving this propoſition form no ſolid objection to its truth.

SECT. V.

OF THE ACTUAL DIVISIBILITY OF MATTER.

PROP. I.

One grain of gold may eaſily be divided into two millions of parts; and a cubic inch into nine billions, five hundred and twenty-three millions, eight hundred and nine thouſand, five hundred and twenty-three parts; each of which may be diſtinctly ſeen by the naked eye.

PROP. II.

A particle of ſand, ſo ſmall that a million of ſuch particles may be contained in a cubic inch, does contain two millions, one hundred and eleven thouſand, and four hundred ſuch parts as a ſingle grain of copper may be divided into; and yet be viſible by the naked eye.

PROP. III.

If an inch were divided into a trillion of parts, the particles of ſome odoriferous bodies are leſs in bulk than thirty-eight of theſe parts.

PROP. IV.

If the fluids in animalcula and men are in the ſame proportion to their reſpective bodies, a ſpace equal in bulk to the ſmalleſt grain of ſand that is viſible by the naked eye, would contain more of the globules of ſome of the fluids in animalcula, than a ſpace equal in bulk to two hundred and ſixty-ſix of the higheſt mountains in the earth would contain grains of ſand.

Of other proofs of the actual diviſibility of matter into parts ſo minute as to elude the conception of man.

SECT. VI.

OF THE PRIMARY PARTICLES OF MATTER.

PROP. I.

All bodies, however different in qualities or forms, conſiſt of a few kinds of unchangeable particles variouſly combined together.

Of the commonly ſuppoſed elements, Earth, Water, Air, Fire.

PROP. II.

The commonly ſuppoſed elements are not atoms: they ſeem to conſiſt of many parts; ſo that the original elements are not known. Perhaps they are but two; from the various modifications of which all the diverſity of bodies is produced.

Of the difficulty of reducing bodies to their firſt principles, atoms, or primary particles: and of the compoſition of bodies in general.

SECT. VII.

OF THE SECONDARY PARTICLES OF MATTER.

PROP. I.

Matter under every form produced by the operations of nature or art, that we are acquainted with, may be arranged in the following manner.

CLASS I.

SALINE BODIES.

ORDER I.

SIMPLE SALTS.

DIVISION I.

ACIDS.

PRIMARY ACIDS.

Genus.
1. Vitriolic Acid.
2. Nitrous Acid.

Genus.
3. Muriatic Acid.
4. Acetous Acid.

SECONDARY ACIDS.

Genus.
1. Acidum Tartari.
2. Acid. Eſſen. Vegetab.
3. Acidum Bituminis.
4. Acidum Boracis.
5. Acidum Olei.

Genus.
6. Acidum Phoſphori.
7. Acidum Inſectorum.
8. Acidum Stomachi.
9. Acidum Spati.
&c.

DIVISION II.

ALKALIS.

SUBDIVIS. I.

FIXT ALKALIS.

Genus.	Genus.
1. Foſſil Fixt Alkali.	2. Vegetable Fixt Alkali.

SUBDIVIS. II.

VOLATILE ALKALI.

Genus.
1. Alkali Volatile.

ORDER II.

COMPOUND SALTS.

DIVISION I.

NEUTRAL SALTS.

	Genus.	
Vit. Acid.	1. Vitriolated Tartar.	Veg. Alk.
Vit. Acid.	2. Glauber's Salt.	Foſſ. Alk.
Vit. Acid.	3. Vitriolic Ammoniac.	Vol. Alk.
Nit. Acid.	4. Common Nitre.	Veg. Alk.
Nit. Acid.	5. Cubic Nitre.	Foſſ. Alk.
Nit. Acid.	6. Nitrous Ammoniac.	Vol. Alk.
Mur. Acid.	7. Sal digeſt. Silvii.	Veg. Alk.
Mur. Acid.	8. Common Salt.	Foſſ. Alk.
Mur. Acid.	9. Com. Salt Ammoniac.	Vol. Alk.
Veg. Acid.	10. Regenerated Tartar.	Veg. Alk.
Veg. Acid.	11. Polychreſt of Rochelle.	Foſſ. Alk.
Veg. Acid.	12. Spiritus Mindereri.	Vol. Alk.

	Genus.	
Mur. Acid.	13. Sedative Salt.	Phlog.(incert.)
Sal Sedativ.	14. Borax.	Foſſ. Alk.

DIVISION II.

EARTHY SALTS.

	Genus.	
Vit. Acid.	1. Gypſa.	Ter. calc.
Vit. Acid.	2. Sal cathart. amar.	Magneſia.
Vit. Acid.	3. Alumen.	Argilla.
Vit. Acid.	4. Minera Aluminis.	Argill. &c.
Mur. Acid.	5. Sal Ammon. Fixum.	Ter. calc.

DIVISION III.

METALLIC SALTS.

	Genus.	
Vit. Acid.	1. Turpethum minerale.	Hydrarg.
Vit. Acid.	2. Vitriolum coeruleum.	Cuprum.
Vit. Acid.	3. Vitriolum viride.	Ferrum.
Vit. Acid.	4. Vitriolum Album.	Zincum.
Nit. Acid.	5. Cauſticum lunare.	Argentum.
Nit. Acid.	6. Mercurii ſolutio.	Hydrarg.
Nit. Acid.	7. Veneris ſolutio.	Cuprum.
Nit. Acid.	8. Saturni ſolutio.	Plumbum.
Nit. Acid.	9. Martis ſolutio.	Ferrum.
Nit. Acid.	10. Cobalti ſolutio.	Cobaltum.
Nit. Acid.	11. Zinci ſolutio.	Zincum.
Nit. Acid.	12. Nickeli ſolutio.	Nickelum.

	Genus.	
Mur. Acid.	13. Luna cornea.	Argentum.
Mur. Acid.	14. Mercurius corroſivus.	Hydrarg.
Mur. Acid.	15. Saturnus corneus.	Plumbum.
Mur. Acid.	16. Atrament. ſympath.	Cobaltum.
Veg. Acid.	17. Aerugo.	Cuprum.
Veg. Acid.	18. Saccharum Saturni.	Plumbum.

ORDER III.

SALINE PETREFACTIONS.

	Genus.	
Salia.	1. Petrefacta vegetabilia.	Veg. vel part. veg.
Salia.	2. Petrefacta animalia.	Anim. vel partes.

CLASS II.

EARTHY BODIES.

ORDER I.

HOMOGENEOUS EARTHS.

DIVISION I.

ABSORBENT EARTHS.

SUBDIVIS. I.

CALCAREA.

	Genus.	
Ter. Calc.	1. Terra Calcarea.	Aer. Fac.

	Genus.	
Ter. Calc.	2. Teſtacea.	Aer Fac.
Ter. Calc.	3. Lithophyta.	Ol. Anim.
Ter. Calc.	4. Gypſa.	Vitr. Acid.
Ter. Calc.	5. Sal Ammon. Fixum.	Mur. Acid.
Ter. Calc.	6. Oſteocolla.	Ter. Cryſt.
Ter. Calc.	7. Lapis ſuillus.	Phlogiſton.
Ter. Calc.	8. Lapis hepaticus.	Phl. Vit. Ac.
Ter. Calc.	9. Marga.	Argilla.
Ter. Calc.	10. Min. ferri alba.	Ferrum.
Ter. Calc.	11. Coeruleum mont.	Cuprum.
Ter. Calc.	12. Ceruſſa nativa.	Plumbum.
Ter. Calc.	13. Petrefacta calc.	Corp. varia.

SUBDIVIS. II.

MAGNESIA.

	Genus.	
Magneſia.	1. Terra vegetabil. exuſtor.	
Magneſia.	2. Sal cathartic. amar.	Vitr. Acid.

SUBDIVIS. III.

ALUMINOUS EARTH.

	Genus.	
Argilla.	1. Alumen.	Vitr. Acid.
Argilla.	2. Minera aluminis.	Idem, et corp. heterog.

SUBDIVIS. IV.

BONE-EARTH.

	Genus.	
Terra (incert.)	1. Cineres oſſ. ſeu corn.	Liq. Inſip.

SUBDIVIS. V.

FLESH-EARTH.

	Genus.	
Terra (incert.)	1. Cineres ſang. carn.	Liq. Aſtring.

DIVISION II.

CRYSTALLINE-EARTHS.

	Genus.	
Ter. Cryſt.	1. Corpora cryſtal.	Metal. Phlog. (incert.)
Ter. Cryſt.	2. Petrefacta cryſt.	Part. veg. (incert.)

DIVISION III.

GRANATE-EARTH.

	Genus.	
Ter. Gran.	1. Granatus Martialis.	Ferrum.
Ter. Gran.	2. Granatus Jovis.	Fer. et Stan.
Ter. Gran.	3. Granatus Saturni.	Fer. et Plumb.
Ter. Gran.	4. Baſaltes.	Fer. (incert.)

DIVISION IV.

ARGILLACEOUS-EARTH.

	Genus.	
Argilla.	1. Argilla communis.	Vitr. Acid. et fer.
Argilla.	2. Argilla apyra.	Phlogiſton.
Argilla.	3. Argilla vitreſcens.	Phlog. (incert.)
Argilla.	4. Argilla ferrea.	Ferrum.
Argilla.	5. Petrefacta argillacea.	Partes veget.

DIVISION V.

MICACEOUS-EARTH.

	Genus.	
Ter. Mic.	1. Venice talc.	Argil. (incert.)
Ter. Mic.	2. Solar talc.	Ferrum.

DIVISION VI.

FLUOR-EARTH.

	Genus.	
Ter. fluor. min.	1. Fluor mineralis.	Phlog. (incert.)

DIVISION VII.

ASBESTINE-EARTH.

	Genus.	
Ter. Aſbes.	1. Aſbeſtus.	Argil. (incert.)

DIVISION VIII.

ZEOLITE-EARTH.

	Genus.	
Ter. Zeol.	1. Zeolites purus.	(Incert.)
Ter. Zeol.	2. Lapis lazuli.	Fer. Arg. (incert.)

DIVISION IX.

MANGANESE-EARTH.

	Genus.	
Ter. Mang.	1. Manganeſia pura.	(Incert.)

	Genus.	
Ter. Mang.	2. Manganeſia atra.	Ferrum.
Ter. Mang.	3. Spuma lupi.	Ter. Stan.

ORDER II.

HETEROGENEOUS EARTHS.

DIVISION I.

CLOSE-GRAINED.

	Genus.	
Ter. Calc.	1. Ophites.	Ter. argil.
Quartz.	2. Stellſten.	Mica.
Quartz.	3. Norca.	Mica et Granat.
Quartz.	4. Whetſtone.	Mica et argil.
Steatites.	5. Telgſten.	Mica.
Jaſp. et Spat.	6. Porphyry.	Mica et Baſaltes.
Jaſp. et Fer.	7. Trapp.	Argil. (incert.)
Jaſp. Mart.	8. Amygdaloides.	Fer. Spat. et calc.
Mica.	9. Gronſten.	Hornblende.
Spat. et Mic.	10. Granite.	Quartz. ſteat. &c.

DIVISION II.

GRANULOUS.

	Genus.	
Ter. conglut.	1. Free-ſtone.	Calc. Quartz. Mic. &c.
(Incert.)	2. Breccia.	Frag. Lapid.

DIVISION III.

SCORIAE.

	Genus.	
Glaſs ſlag.	1. Lava.	Ciner. vulcan.
Glaſs ſlag.	2. Pearl ſlag.	Ciner. vulcan.
Glaſs ſlag.	3. Pumice ſtone.	(Incert.)
Glaſs ſlag.	4. Rhine milnſtone.	(Incert.)
Glaſs ſlag.	5. Iceland agate.	Fer. (incert.)

DIVISION IV.

MOULDS.

	Genus.	
Ter. Argil.	1. Humus vegetabilis.	Vegetab. putrida.
Ter. Argil.	2. Humus animalis.	Anim. putrida.

CLASS III.

INFLAMMABLE BODIES.

ORDER I.

PHLOGISTON.

	Genus.	
Ignis.	1. Pure inflammable matter.	(Incert.)

ORDER II.

SULPHUR.

	Genus.	
Phlogiſton.	1. Sulphur purum.	Vitr. Acid.
Sulphur.	2. Sulphuris minera.	Foſſilia.

ORDER III.

CHARCOAL.

	Genus.	
Phlogiſton.	1. Carbo Lignarius.	Ter. alk.

ORDER IV.

ARDENT SPIRIT.

	Genus.	
Phlogiſton.	1. Spiritus ardens.	Aqua.
Phlog. et acid.	2. Aether.	Minus aquae.

ORDER V.

OIL.

DIVISION I.

FOSSIL OIL.

	Genus.	
Foſſ. oil.	1. Naphta.	
Foſſ. oil.	2. Petroleum.	Corp. heterog.
Foſſ. oil.	3. Bitumen.	Ter. alk.
Foſſ. oil.	4. Jett.	Partes ligneae.
Foſſ. oil.	5. Foetid-peat.	Vegetabilia.
Foſſ. oil.	6. Pit-coal.	Sulph. alumen.
Foſſ. oil.	7. Amber.	Vitr. et mur. acid.

DIVISION II.

VEGETABLE OIL.

SUBDIVIS. I.

EXPRESSED VEGETABLE OIL.

Genus.		
Ol. veg.	1. Oleum veg. viſcidum.	Sine part. veg.

SUBDIVIS. II.

ESSENTIAL VEGETABLE OIL.

Genus.		
Ol. veg.	1. Oleum veg. ſubtile.	Partic. odorif.

Of Empyreumatic Vegetable Oil.

Of Gums, Reſins, Sugar, and Camphor.

DIVISION III.

ANIMAL OIL.

SUBDIVIS. I.

EXPRESSED ANIMAL OIL.

Genus.		
Ol. anim.	1. Ol. anim. adipoſum.	Acid. anim.

SUBDIVIS. II.

ESSENTIAL ANIMAL OIL.

Genus.		
Ol. anim.	1. Ol. anim. eſſentiale.	Alkali vol.

Of Empyreumatic Animal Oil.

Of Milk, Gall, Faeçes; Unctuous and Gelatinous Animal Subſtances.

ORDER VI.

PHOSPHORUS.

	Genus.	
Phoſ. acid. oil.	1. Kraft's phoſ. urinae.	Mur. ac. alk.
Idem.	2. Margraff's phoſ. veg.	Idem.
Alum.	3. Homberg's phoſ.	Phlogiſton.

Of Noctilucae.

FOSSIL.

Gypſeous Earths. Nitrous Acid and Chalk. Fixt Sal Ammoniac. Calx viva et Sulphur. Multa corpora in fuſione. Adamas luce ſaturatus. Nonnulli lapides colliſione.

VEGETABLE.

Lignum putridum. Folia nonnulla.

ANIMAL.

Piſces putridae. Caro putrida. Inſectae marinae. Cicindela. Oculi anim. nonnul. Panni nonnulli.

ELECTRICAL.

Electric Matter, excited by art or nature, when luminous.

Of inflammable Air; Mineral, Vegetable, and Animal.

Of Woods.

CLASS IV.

METALLIC BODIES.

DIVISION I.

METALS.

Perfect.

Genus.

1. Gold.
2. Platina.
3. Quickſilver.
4. Silver.

Imperfect.

Genus.

5. Lead.
6. Copper.
7. Iron.
8. Tin.

DIVISION II.

SEMI-METALS.

Genus.

1. Biſmuth.
2. Nickel.
3. Zinc.

Genus.

4. Regulus Antimonii.
5. Regulus Arſenici.
6. Regulus Cobalti.

DIVISION III.

ORES.

SUBDIVIS. I.

METALLIC ORE.

Genus.

1. Minera Auri.

Genus.

2. Minera Platinae.

Genus.
3. Minera Mercurii.
4. Minera Argenti.
5. Minera Plumbi.

Genus.
6. Minera Cupri.
7. Minera Ferri.
8. Minera Stanni.

SUBDIVIS. II.

SEMI-METALLIC ORE.

Genus.
1. Minera Biſmuthi.
2. Minera Nickeli.
3. Minera Zinci.

Genus.
4. Minera Antimonii.
5. Minera Arſenici.
6. Minera Cobalti.

CLASS V.

WATER.

DIVISION I.

SIMPLE WATER.

Genus.
1. Aerial Water.

Genus.
2. Terreſtrial Water.

DIVISION II.

COMPOUND WATER.

SUBDIVIS. I.

SALINE WATER.

Genus.
1. Acid Water.
2. Alkaline Water.
3. Nitrous Water.

Genus.
4. Sea Water.
5. Salt Spring Water.

SUBDIVIS. II.

EARTHY WATER.

Genus.
1. Saline Earthy.

Genus.
2. Calcareous.

SUBDIVIS. III.

PHLOGISTIC WATER.

Genus.
1. Sulphureous Alcaline.
2. Sulphureous Glauber.
3. Sulphureous Sea Salt.

Genus.
4. Sulphureous Calcar.
5. Oily.
&c.

SUBDIVIS. IV.

METALLIC WATER.

Genus.
1. Cupreous.

Genus.
2. Ferruginous.

CLASS VI.

AIR.

DIVISION I.

COMMON AIR.

Genus.
1. Pure Com. Air.
Aer Pur. 2. Mixed Com. Air. Corp. heterog.

DIVISION II.

FACTITIOUS AIR.

SUBDIVIS. I.

NOXIOUS FAC. AIR.

Genus.

1. Vitriolic Air.
2. Nitrous Air.
3. Muriatic Air.
4. Alkaline Air.
5. Vinous Air.
6. Apoſeptic Air.
7. Stillatitious Air.
8. Calcareous Air.

Genus.

9. Mephitic Air.
10. Spa-Water Air.
11. Inflammable Air.
12. Fulminating Air.
13. Calces Air.
&c.
14. Pulmonic Air.
15. Aduſt Air.

SUBDIVIS. II.

SALUTARY FAC. AIR.

Genus.

1. Salpetrous Air.
2. Sedative Air.
3. Vitrocupreous Air.
4. Solminium Air.

Genus.

5. Mercurial Air.
6. Vitriolminium Air.
7. Nitro-igneous Air.
&c.

CLASS VII.

FIRE.

Genus.

1. Fire producing heat.
2. Fire producing light.
3. Fire producing heat and light.
4. Latent fire.

CHARACTERS

Of the above Claſſes, Orders, Diviſions, and Subdiviſions; and of ſome of the Genera.

CLASS I.

SALINE BODIES.

Thoſe bodies which are ſaltiſh to the taſte, and ſoluble in water.

ORDER I.

SIMPLE SALTS.

Such ſaline bodies as are not decompoſed by the common operations of art; being only ſimple in oppoſition to the next order.

DIVISION I.

ACIDS

Have a ſour taſte, and give a red tinge to moſt of the blue juices of vegetables.

Genus 1.

THE VITRIOLIC ACID,

When pure, is without ſmell, without colour and in weight to water, of the ſame bulk, as 18,775 to 10,000: unites with water, and effer-veſces. It may be more than doubled in weight by the water which it imbibes from the air: is not volatile: has different appearances according to its purity, and the nature of the bodies with which it is mixed: acts upon alkalis, earths, inflammable, metallic, vegetable, and animal bodies; and produces compounds, which have various properties and forms when cryſtallized.

Genus 2.

THE NITROUS ACID

Is eaſily diſtinguiſhed from the laſt by the following properties. It has a peculiar ſmell: exhales perpetually in vapours: is of a fiery yellow colour: imbibes leſs water from the air: and, when ſtrong, is in weight to water as more than 1 and an half to 1.

Genus 3.

THE MURIATIC ACID

Gives a weak ſaffron-like ſmell, which is eaſily diſtinguiſhed from that of the other acids. It is of a whitiſh colour: is in weight to water as 13 to 10: unites with water; but not ſo much as the vitriolic acid: when very pure it diſſolves tin and lead: when leſs ſo, copper, iron, zinc, and the regulus of antimony. When mixed with the nitrous acid, it makes aqua regia. It unites with ſilver diſſolved in aqua fortis, and with lead in aqua regia; falling with them to the bottom in a white ſpongy maſs.

Genus 4.

THE ACETOUS ACID

Is procured from vegetables: has a well known taſte and ſmell: is clear; and is in weight to water as 1,011 to 1,000. It acts not upon gold, platina, mercury, or ſilver. It corrodes copper, zinc, and lead: is not ſo ſimple, fixed, and capable of being concentrated as the mineral acids are.

The ſecondary acids are produced by the union of the primary with the bodies from which they are obtained; or with an unknown acid, more ſimple than the primary. The liſt of them is not complete. New acids, or varieties of the primary acids with their combinations, are often diſcovered.

DIVISION II.

ALKALIS

Have a pungent acrid taſte, very different from that of acids; and make the blue juice of vegetables green.

SUBDIVIS. I.

FIXT ALKALIS

Require an intenſe heat to diſſipate them.

Genus 1.

FOSSIL FIXT ALKALI

Unites with acids, and forms neutral ſalts: unites with oils; gives them the property of mixing with water; and, by being mixed with oils, forms ſoap: imbibes moiſture from the air, and becomes fluid and cauſtic: in a ſolid cryſtallized ſtate, is mild: when mild, effervesces with acids: ſhoots into cryſtals of a priſmatical figure, which fall in the air: is fuſible in a moderate degree of fire: ſerves to fuſe all the earths: in a certain degree of fire melts with the earths into a glaſs: in a great proportion communicates its properties to the earths which it has diſſolved: unites perfectly with abſorbent earths: decompoſes the ſalts formed of the volatile alkali, and of earthy or metallic bodies.

Genus 2.

VEGETABLE FIXT ALKALI

Has nearly the ſame properties with the laſt; but is more acrid, and forms different neutral ſalts, as contained in Order II. Diviſion I.

SUBDIVIS. II.

VOLATILE ALKALI

Is diſſipated by a ſmall degree of heat.

Genus I.

ALKALI VOLATILE

Differs from the fixt alkalis in the following properties. It unites leſs ſtrongly with other bodies: is ſo volatile, that with a heat leſs than that of boiling water, it may be diſſipated entirely: and ſo pungent to the ſmell, that it can be endured but for a very ſhort time. It forms cryſtals when it concretes.

ORDER II.

COMPOUND SALTS.

Saline bodies, compoſed of acids joined to alkalis; or to earths; or to metallic bodies.

DIVISION I.

NEUTRAL SALTS.

Salts compoſed of acids joined to alkalis, and which have properties different from both.

DIVISION II.

EARTHY SALTS.

Such as are compoſed of acids joined to earths.

DIVISION III.

METALLIC SALTS

Are compoſed of acids joined to metallic bodies.

ORDER III.

SALINE PETREFACTIONS.

Vegetable or animal bodies, depoſited in the earth, and united to ſaline bodies.

CLASS II.

EARTHY BODIES

Are not malleable; not inflammable; not fuſible in a common degree of furnace-fire; or if fuſible, will run into a glaſſy form.

ORDER I.

HOMOGENEOUS EARTHS.

Earths which conſiſt of parts thoroughly blended, and uniformly mixed.

DIVISION I.

ABSORBENT EARTHS.

Such as unite with acids, and deſtroy their acidity.

SUBDIVIS. I.

CALCAREOUS EARTHS

When burnt in the fire become porous, and gradually diſſolve in the air into quick-lime, but ſpeedily if water is added. They cannot be vitrified in a cloſe fire, without ſome heterogeneous addition.

SUBDIVIS. II.

MAGNESIA

Is not convertible by fire into quick-lime: diſſolves readily in the vitriolic acid into a limpid bitter purgative liquor; whereas calcareous earths form with that acid, an inſipid ſelenites; and other earths ſtiptic compounds.

SUBDIVIS. III.

ALUMINOUS EARTH

Diſſolves in every acid: with the vitriolic, forms alum; with the nitrous, a compound reſembling it; and with the vegetable, one leſs aſtringent and diſagreeable to the taſte.

SUBDIVIS. IV.

BONE-EARTH

Is not convertible into quick-lime; and gives no taſte to water though highly calcined.

SUBDIVIS. V.

FLESH-EARTH,

Like the laſt, is not convertible into quicklime; but is perfectly diſſoluble in the mineral acids: and forms with the vitriolic an aſtringent liquor different from that of Subdiviſ. II.

DIVISION II.

CRYSTALLINE-EARTH

Does not efferveſce with acids: does not, when burnt, fall into a powder in the air, or in water; but becomes more porous, and full of fiſſures: when free from heterogeneous matter, is not fuſible in a common furnace-heat: is eaſily fuſed by the addition of fixt alkali.

DIVISION III.

GRANATE-EARTH

Is vitrifiable with veg. fixt alkali: is different in the facility of fuſion, as more or leſs tranſparent, or metalline; the moſt tranſparent being fuſible in a blaſt-furnace without any addition.

DIVISION IV.

ARGILLACEOUS-EARTHS

Harden in the fire; and have fine conſtituent parts: ſome ſoften in water; and, when they have imbibed a ſmall quantity, become ductile: ſome crack in water when they have imbibed as much as they can; but are not ſoftened: ſome imbibe water and do not crack: ſome imbibe no water at all.

DIVISION V.

MICACEOUS-EARTH

Is compoſed of lamina which are thin, ſcaly, flexile, gloſſy, and which in a violent heat become brittle and ſhrivel up: is with difficulty brought to a pure glaſs, without an addition; but eaſily with borax or alkali, eſpecially the ſecond kind.

DIVISION VI.

ARGILLACEOUS-EARTH

Strikes no fire with ſteel: effervеſces not with acids before or after burning; tho, in the laſt caſe, an inflammable ſubſtance or alkali ſhould be added. It cracks, but does not melt, in a ſtrong fire, without the addition of other bodies; but, when mixed with other earths, is eaſily brought into fuſion.

DIVISION VII.

ASBESTINE-EARTH

Is flexile in large pieces: ſtrikes no fire with ſteel: is not acted upon by acids: becomes brittle, but is not fuſed in a common furnace; is eaſily fuſed by an addition of borax.

DIVISION VIII.

ZEOLITE-EARTH

Strikes no fire with ſteel, tho harder than fluors: eaſily melts into a ſoft ſpumous glaſs: does not efferveſce with phoſphorine ſalt like lime, nor with borax like gypſum: does not efferveſce with the vitriolic and nitrous acids, but is gradually diſſolved. If the concentrated oil of vitriol is poured on it, when pulverized, an effervescence enſues, and the parts of the powder adhere.

DIVISION IX.

MANGANESE-EARTH

Has a ſooty appearance, but when broken a metalline: communicates a colour to vitrifications and ſolutions by ſalts: explodes with common nitre: with vitrifying additions and phoſphorine ſalt diſſolves and effervesces in the fire: does not effervesce with aqua fortis, but the aqua fortis extracts the black colour, which with alkali ſubſides in the form of a white powder. The colours which it gives to glaſs, are eaſily diſcharged by arſenic, and by fire.

All the properties of this, and of ſome of the other earths, are not fully aſcertained.

ORDER II.

HETEROGENEOUS EARTHS.

Such as conſiſt of parts not thoroughly blended, nor uniformly mixed.

DIVISION I.

CLOSE-GRAINED.

Heterogeneous earths ſo cloſely united, that the parts are of an uniform appearance, and the cementing matter is not eaſily perceived.

DIVISION II.

GRANULOUS EARTHS.

Their component parts are larger than thoſe of the laſt, and more unequal; and the cementing matter is more eaſily diſtinguiſhed.

DIVISION III.

SCORIAE.

Bodies produced by ſubterraneous fires; or which have the ſame properties with bodies that have undergone great degrees of heat in an artificial furnace.

DIVISION IV.

MOULDS

Are indiſſoluble in acids: ſomewhat tenacious when moiſtened with water: friable when dry: and acquire in the furnace no additional hardneſs.

CLASS III.

INFLAMMABLE BODIES.

Such bodies as will take fire when a burning body is applied to them; and communicate the flame to the reſt of the ſubſtance, tho the inflaming body be removed.

ORDER I.

PHLOGISTON.

The inflammable principle, or the principle of inflammability. It cannot be got ſimple or detached, but can be conveyed from one body to another, ſo as to make part of its compoſition. It communicates neither heat nor light, and changes not the ſolidity of the body to which it is joined; but, upon the application of fire, renders it much more fuſible. Perhaps it is fire in a quieſcent ſtate, and united to a body which ſerves it as a baſis for a ſecondary principle.

ORDER II.

SULPHUR

Is not ſoluble in water, in ardent ſpirits, nor in acids; but is ſoluble in oils.

ORDER III.

CHARCOAL

Has the following properties. It is unalterable by acids, and by every body excepting fire; but when on fire, the mineral acids act upon it, if they are combined with other bodies.

ORDER IV.

ARDENT SPIRITS

Burn without the leaſt ſmoke or ſoot: leave no ſediment or coal: are perfectly miſſible with water: and diſſolve eſſential oils.

ORDER V.

OIL

Conſumes with flame and ſmoke: leaves a coal after diſtillation: is compoſed of phlogiſton, an acid and an earth combined in a manner unknown; or with an unknown ſubſtance.

DIVISION I.

FOSSIL OIL.

Oil found in the earth. It is changed by the mineral acids, and by heterogeneous bodies, into the genera of this diviſion.

DIVISION II.

VEGETABLE OIL

Is procured from vegetables: and is changed by the mineral acids, and heterogeneous bodies, into the genera of this diviſion.

SUBDIVIS. I.

EXPRESSED VEGETABLE OIL

May be known by the following properties. It is not miſſible with ardent ſpirits; but eaſily with eſſential oils. It is not volatile in the heat of boiling water. It is inſipid and inodorous when properly made.

SUBDIVIS. II.

ESSENTIAL VEGETABLE OIL

Is entirely volatile in the heat of boiling water; and has the ſmell and taſte of the vegetables from which it is drawn.

DIVISION III.

ANIMAL OIL.

Oil procured from animal bodies.

SUBDIVIS. I.

EXPRESSED ANIMAL OIL

Is procured from particular parts of animals. It contains an acid which may be ſeparated by fire, or by the rancidity which it acquires with time.

SUBDIVIS. II.

ESSENTIAL ANIMAL OIL.

An oil obtained from almoſt all the parts of an animal body. It contains a little alkali, but no acid.

Animal oils, when burning, are eaſily diſtinguiſhed by their ſmell.

ORDER VI.

PHOSPHORUS.

A body which is luminous in the dark; and which will burn in the air without the application of a burning body, or any of the common methods of producing fire.

Noctilucae are luminous bodies; but they do not burn in the ſame manner.

CLASS IV.

METALLIC BODIES.

Bodies which are not miſcible with water, nor inflammable; which are fuſible in the fire, and return to their former texture when cold; which are bright when freſh broken or poliſhed.

DIVISION I.

METALS.

Metallic bodies that are malleable. They are diſtinguiſhed into perfect and imperfect. The firſt ſuffer no change from the joint effect of the air and fire in the hotteſt furnace. The laſt are unaltered by the ſtrongeſt furnace-fire when the air is excluded; but in open veſſels are changed into an earth which has no metallic properties.

Genus 1.

GOLD

Has a bright yellow colour: is in weight to water as 19,640 to 1,000, when of the ſame bulk: is of all bodies the moſt ductile: has little elaſticity: is almoſt as ſoft as lead: is eaſily united to quickſilver: ſtands the effect of air, water, and the greateſt furnace-heat unchanged: is diſſolved by aqua regia: precipitated by volatile alkali and nitrous acid: retains its ductility tho joined to a ſmall proportion of ſilver, platina, copper, or zinc: but is made brittle by the fumes of tin.

Genus 2.

PLATINA

Is diſtinguiſhed from gold by the following properties. Its colour is white. When unmixed, its weight to water is as 17,000 to 1,000. When mixed with certain metals, as 22,000 to 1,000. It is harder and leſs coherent than gold. When mixed with other metals, or ſemi-metals, it is eaſily brought into fuſion: when pure, with the utmoſt difficulty. It does not unite with quickſilver, but by means of the muriatic acid. It is diſſolved in aqua regia, and precipitated with tin, and yields not the mineral purple.

Genus 3.

QUICKSILVER.

This body is a metal, becauſe it is malleable; tho it is only ſo in a great degree of cold. It is white, with a luſtre like poliſhed ſteel. When pure, its weight to water is as 14,000 to 1,000. Tho it eaſily exhales into ſubtile penetrating fumes, and tho it is convertible by common furnace-fire into the appearance of a calx, yet its parts are not decompoſed. It unites with all the metals and ſemi-metals, except cobalt and nickel. It diſſolves in the nitrous acid, and in the vitriolic by boiling: is precipitated by an alkali; is not affected by the muriatic acid, unleſs previouſly diſſolved by other acids. It unites with ſulphur by grinding.

Genus 4.

SILVER.

Its colour, when pure, is a ſhining white. Its weight to water as 11,091 to 1,000. It is ductile, tho not ſo much ſo as gold: unalterable in air, water, or the furnace: may be diſſolved by the nitrous acid, and in the vitriolic when boiling: if precipitated from the acid of nitre by common ſalt, or its acid, unites ſo ſtrongly with the muriatic acid, that it melts with it into a maſs like glaſs:

does not unite with nickel by fuſion: unites eaſily with quickſilver: is acted upon by hepar ſulphuris: imbibes the fumes of ſulphur: is exhaled by volatile metals and acids: melts more eaſily than copper.

Genus 5.

LEAD,

When freſh broken, or cut, is of a bluiſh white; but turns blackiſh in the air. Its weight to water is as 11,325 to 1,000. It eaſily burns to a calx; which, according to the degree of fire, is white, yellow, or red. Its calx melts to a glaſs more eaſily than any other metallic calx; and ſerves to bring other bodies, and the imperfect metals, into fuſion. It diſſolves in the vitriolic acid, in the nitrous, and in the vegetable, in alkaline ſolutions, and expreſſed oils. It gives a ſweet taſte to ſolutions: unites with quickſilver: has the ſame effect as ſilver with the muriatic acid: does not unite with iron, when joined to it in the fire, without ſome other addition: melts before it is red hot. Its calx may be reſtored to the metallic ſtate, by the vegetable fixt alkali.

Genus 6.

COPPER

Has a reddiſh colour: is in weight to water as 9,000 to 1,000, when of the fineſt kind: is ductile and ſoft. Its calx, when diſſolved by acids, is green; and by alkaline ſalts, is blue. It is eaſily calcined in the fire into a blackiſh ſubſtance, which becomes red by rubbing. When melted with glaſs, it firſt acquires a reddiſh brown colour, and afterwards a tranſparent green. It is ſoluble in all the acids, and in all alkaline ſolutions. It can be precipitated in a metallic ſtate: is not eaſily united with quickſilver: unites ſtrongly with zinc and tin; and the compoſition is braſs, bell-metal, &c. It is eaſily diſſolved by lead-glaſs; and melts with a leſs heat than iron.

Genus 7.

IRON.

Its colour is well known, when poliſhed, and unpoliſhed. Its weight to water, when of the fineſt kind, is as 8,000 to 1,000. It becomes magnetical. It grows ductile by hammering, and by being often heated in the fire. It is diſſolved by all ſaline bodies, by water, and their effluvia. It is melted with difficulty; calcines eaſily into a black calx; which, when pounded, is of a deep red colour; and which may be diſſolved by the muriatic acid, and aqua regia. This calx, in a great quantity, gives a blackiſh colour to glaſs; and in a ſmall quantity, a greeniſh. There are three ſorts of iron in common uſe, caſt iron, forged iron, and ſteel.

Genus 8.

TIN.

The weight of tin to water is as 7,400 to 1,000, when of the pureſt kind. Its colour is greyiſh. It is the moſt fuſible of all the metals, and the leaſt ductile. It has a particular ſmell: is eaſily calcined to white aſhes; which become a fourth part heavier than the metal, and eaſily mix in glaſs compoſitions. It unites with all metals and ſemi-metals, and renders them brittle, except lead, biſmuth, and zinc. It eaſily unites with quickſilver: diſſolves in the vitriolic and muriatic acids, and in aqua regia; but is only corroded into a white powder by the nitrous. It is gradually corroded by the vegetable acid, by ſoaps, and by pure alkalis. It diſſolves in aqua regia: and heightens the colour of cochineal.

DIVISION II.

SEMI-METALS.

Metallic bodies which are not malleable, and which loſe their metallic properties, in a certain degree of fire.

Genus 1.

BISMUTH

Is of a pale yellow colour: of a laminated texture: ſoft under the hammer, and yet very brittle: is in weight to water as 9,700 to 1,000. It diſſolves in aqua fortis, without imparting any colour; but to aqua regia gives red. It eaſily unites with quickſilver: mixes with all metallic bodies, except cobalt and zinc; and the compoſition is white and brittle: is ſpeedily fuſed, and is volatile in the fire. Its glaſs is of a yellowiſh brown colour.

Genus 2.

NICKEL.

The texture of nickel is ſolid, its fractures ſhining, its colour white inclining to red, its weight to water as 8,500 to 1,000. It calcines into a green calx, which tinges glaſs with a tranſparent reddiſh brown colour. It eaſily diſſolves in aqua fortis, aqua regia, and in the marine acid; but with more difficulty in the vitriolic; tinging all theſe ſolutions with a deep green. It eaſily unites with ſulphur, and forms with it a regulus. It unites with all the metals except quickſilver and ſilver. To the laſt it only adheres. It requires near the ſame degree of heat with gold or copper to bring it into fuſion.

Genus 3.

ZINC.

In colour it reſembles lead; but is not ſo ſoon tarniſhed by the air. It ſeems to be compoſed of flat pyramids. Its weight to water is as 7,000 to 1,000, when of the pureſt kind. It unites with all the metals except biſmuth, and makes them volatile. It eaſily incorporates with gold or copper; to which laſt it gives a yellow colour. It is diſſolved by all the acids: unites with quickſilver more eaſily than with copper: melts in the fire before it has acquired a glowing heat: and when it has acquired that, burns with a flame of a changeable colour.

Genus 4.

REGULUS ANTIMONII

Has a white colour, like ſilver. Its weight to water is as 7,500 to 1,000. It is brittle, and breaks into long ſhining planes: is volatile in the fire, and carries off part of other metals when mixed with it, except gold and platina. It calcines into a grey calx, which melts into a glaſs of a reddiſh colour: diſſolves in the marine acid, and aqua regia; but is only corroded by the nitrous into a white calx: unites with quickſilver by a particular preparation: has an emetic quality, when its calx, glaſs, or metal is diſſolved in an acid, except the nitrous.

Genus 5.

REGULUS ARSENICI,

When newly broken, reſembles lead in its colour; but changes ſoon to yellow, and afterwards to black. Its fractures have a laminated appearance. Its weight to water is as 8,000 to 1,000. It diſſolves in the nitrous acid: unites with all metals: and is found mineralized: is volatile in the fire; and ſmells like garlic: is very difficult to be reduced, unleſs mixed with other metals. Its calx eaſily melts to a glaſs; the weight of which is to water as 5,000 to 1,000; and, when mixed with ſulphur, becomes of a yellow, orange, or red colour. Its calx and glaſs are ſoluble in water, and in moſt liquids; but not with the ſame facility. It is poiſonous, eſpecially in the form of a pure calx, or glaſs.

Genus 6.

REGULUS COBALTI

Is of a greyiſh colour; and of a fine grained texture, like tempered ſteel. Its weight to water is as 6,000 to 1,000. It gives a red ſolution in the vitriolic and nitrous acids, and in aqua regia: is fixed in the fire, and becomes black by calcination: gives to glaſs an excellent blue colour, inclining to violet. Its calx is diſſolved in the vitriolic, nitrous, and muriatic acids; in aqua regia, and by the volatile alkali. It is red when united with the calx of arſenic in a calcining heat. It does not unite with quickſilver, nor incorporate with biſmuth by fuſion, without an addition of ſome other body.

DIVISION III.

ORES.

Metallic foſſils, or metallic bodies as found in the earth.

SUBDIVIS. I.

METALLIC ORES.

Metals as found in the earth; either pure, or united to foſſils.

SUBDIVIS. II.

SEMI-METALLIC ORES.

Semi-metals, as found in mines.

CLASS V.

WATER.

A tranſparent body, which is not inflammable, and which is fluid or ſolid in different degrees of heat, according to its different kinds.

DIVISION I.

SIMPLE WATER

Is inſipid, volatile, ſoluble in air; ſo ſubtile, as that, by preſſure, it will paſs thro the pores of the fineſt gold. Its weight to gold is as 1,000 to 19,640. It grows ſolid at thirty-two degrees of heat: diſſolves acids, alkalis, and neutral ſalts; and only a certain quantity of each: when ſaturated with one ſort, will diſſolve a certain quantity of another: when heated, diſſolves and ſuſtains a greater quantity of ſalts than when cold. It mixes eaſily with ardent ſpirits; but not with ſulphur or oil, unleſs they are deprived of the air which they contain: has no effect in diſſolving any metallic ſubſtance, except arſenic, unleſs impregnated with an acid, an alkali, or neutral ſalt; and then it becomes a menſtruum for ſuch metallic ſubſtances as theſe ſalts can diſſolve. Tho the earths are eaſily ſuſpended in it, yet it diſſolves none excepting ſome of the calcareous kind, when reduced to a quicklime, or ſaturated with air; but, when mixed with an acid, it diſſolves all earthy ſubſtances to which ſuch acids are a menſtruum. It is only ſimple when no art is uſed to decompoſe it; for the moſt ſimple yields an earthy and oily matter by a proper analyſis.

Genus 1.

AERIAL WATER.

Water that falls from the atmoſphere in the form of dew, rain, ſleet, ſnow, or hail.

Genus 2.

TERRESTRIAL WATER.

Such as is found on the ſurface, or in the bowels of the earth; and which gives no taſte, or ſmell. The ſpecies of it are, ſpring, pit, river, lake, and ſtagnant water; and theſe are impregnated, more or leſs, with different ſubſtances, according to the ſoils or ſtrata thro which they paſs.

DIVISION II.

COMPOUND WATER.

Water found on the ſurface, or in the bowels of the earth, ſo ſtrongly compounded with ſome mineral ſubſtance, as to affect the organs of taſte or ſmell.

The characters of the ſubdiviſions and genera are plain from their names.

CLASS VI.

AIR.

A fluid body which is very rare compared to water; which is compreſſible; and elaſtic; and which is not deprived of theſe qualities by cold.

DIVISION I.

COMMON AIR.

The air which encompaſſeth the earth; and which is neceſſary to ſuſtain animal life, and vegetable life, and flame.

It forms the ſecond genus when mixed with water, duſt, &c. in ſuch proportions as to be ſeen, ſmelled, or taſted.

DIVISION II.

FACTITIOUS AIR.

Air which is made, or generated, by the action of bodies upon each other.

SUBDIVIS. I.

NOXIOUS FACTITIOUS AIR.

Factitious air which, when perfect in its kind, is fatal to animal life, to vegetable life, and to flame.

Genus 1.

VITRIOLIC AIR.

Air made by joining ſtrong vitriolic acid to oils, copper, ſilver, lead, iron, zinc. It is readily abſorbed by water: is heavier than common air; and precipitates the calcareous earth of lime-water. It diſſolves ice, is abſorbed by charcoal, diſſolves camphor, does not act upon iron, nitre, common ſalt, or ſal ammoniac, and forms a white cloud when joined to the vapour of volatile alkali.

Genus 2.

NITROUS AIR

Is generated by diſſolving in the nitrous acid iron, copper, tin, mercury, ſilver, biſmuth, or nickel; and by diſſolving gold, or regulus of antimony, in aqua regia. When it is mixed with common air, the mixture becomes red, heat is produced, and the bulk of the mixture is leſs than that of the two fluids which compoſe it; but when ſaturated with common air, any further addition produces neither heat nor redneſs, and makes an equal addition to the bulk of the mixture. When it is mixed with factitious air, there is no diminution of its bulk; and when with common air, the diminution is in proportion to the ſalutary quality of the common air. It is diminiſhed a fourth part of its bulk by electric matter, and by expoſure to iron-filings and ſulphur. It is copiouſly abſorbed by ſpirit of nitre; the colour of which is changed to a deep orange, and then to a green. It is abſorbed in a ſmall quantity by water, oil of vitriol, ſpirit of ſalt, vegetable acids, &c.

Genus 3.

MURIATIC AIR.

That air which is diſengaged during the diſtillation of ſpirit of ſalt, by means of oil of vitriol. When mixed with common air, it gives to flame a green or a bluiſh colour. It is diminiſhed in bulk by electric matter: diſſolves ice as quickly as a hot fire: acts upon many inflammable and metallic bodies; and is thereby changed into Genus 11.

Genus 4.

ALKALINE AIR.

By the application of fire to volatile alkali, this air is produced. It is abſorbed by water, diſſolved by ice, unites with moſt of the factitious airs, is increaſed in bulk by electric matter; and, when water is ſaturated with it, the reſiduum is inflammable.

Genus 5.

VINOUS AIR

Is got from vegetable ſubſtances while they undergo the vinous fermentation. 42 cubic inches of beer yield 639 inches of this air: 26 cubic inches of bruiſed apples, 968; and the different wines yield it in various proportions. It diminiſhes common air, is abſorbed by water, makes a precipitation in lime-water, and makes cauſtic alkali mild.

Genus 6.

APOSEPTIC AIR

Eſcapes from animal and vegetable ſubſtances when undergoing the putrefactive fermentation. It conſiſts of two kinds mixed together. One of theſe renders cauſtic alkalis mild, and makes a precipitation in lime-water. The other has the properties of Genus 11.

Genus 7.

STILLATITIOUS AIR.

This air is produced by the diſtillation of animal and vegetable ſubſtances, and it has the general properties of Genus 1. A cubic inch of hog's blood yields 33 inches of this air: half a cubic inch of deer's horn, 117: half a cubic inch of oak, 108: 388 grains of Indian wheat, 270: one cubic inch of peas, 396: one cubic inch of muſtard-ſeed, 270: half a cubic inch of dry tobacco, 153: a cubic inch of coarſe ſugar, 126: a quarter of a cubic inch of human calculus, 516: and 62 pounds of good charcoal, 61.

Genus 8.

CALCAREOUS AIR.

Air got from calcareous bodies by fire or by acids. One dram of chalk diſſolved in two ounces of vinegar produces 150 cubic inches of this air in vacuo: two drams of red coral in one ounce of the muriatic acid, 52 inches. Limeſtone, marble, and magneſia contain this air from a third to a half of their weights. It is from a fourth to a third heavier than common air. Calcareous bodies are converted into quicklime by being deprived of it; and alkalis become more cauſtic, more powerful ſolvents, and do not effervesce with acids. It may be combined with metallic precipitants: is abſorbed by water, expreſſed oils, and ſpirit of wine; and when united with water, diſſolves calcareous earth, magneſia, and iron.

Genus 9.

MEPHITIC AIR

Is generated by nature in caverns, mines, wells, and pits; and by art, as mentioned under Genus 8, &c. It is heavier than common air.

Genus 10.

SPA-WATER AIR

May be obtained in large quantities from all the waters called mineral; and in ſmall quantities from many of the waters of common wells. A conſiderable quantity of common air is uſually mixed with it. Tho at firſt it precipitates the calcareous earth of lime-water, yet it afterwards diſſolves that earth; and tho, by means of it iron is diſſolved in many waters, yet it is precipitated when expoſed to the common air.

Genus 11.

INFLAMMABLE AIR

Is generated by nature in mines where it ſometimes takes fire, and explodes with deſtruction to the miners and their works. It may be produced by art by diſſolving iron, zinc, or tin in the vitriolic acid or muriatic acid, when mixed with water. Inflammable air may likewiſe be produced by diſtilling wax, pitch, ſhells, peas, amber, coals: by placing in vacuo filings of iron, zinc, braſs, or tin, and throwing the ſun's rays upon them by a burning-glaſs: by the putrefaction of animal and vegetable bodies: by adding an acid to liver of ſulphur: by ſaturating common air with volatile alkali, or with the effluvia of ſome reſins: by making electric matter paſs thro oil, ether, ſpirit of wine, or ſpirit of ſal amoniac. It is much lighter than common air, ſo that it is eaſily diſtinguiſhed from Genus 9. When at reſt over water, it is not abſorbed by it. The contact of common air is neceſſary to its inflammation.

Genus 12.

FULMINATING AIR,

This air is produced by the deflagration of nitre with inflammable ſubſtances, by applying fire to metallic precipitants, and by the trituration of mercurial precipitants. It has the properties of Genus 2; or of ſome of the other genera in various proportions.

Genus 13.

CALCES AIR.

This air is obtained by the application of fire to lead and minium: by the revival of the calx of lead by electric matter: by putting minium and charcoal in the focus of a burning-glaſs. It has in general the character of the calcareous, but contains a larger portion of common air.

Noxious factitious air may be obtained from many other bodies. The different kinds are often mixed with, and may be converted into, each other. In general they have the properties of the bodies from which they are obtained; but ſometimes acquire new ones.

Genus 14.

PULMONIC AIR

Is generated by reſpiration; that is, common air is converted into this air by paſſing thro the lungs of animals in breathing. It is leſs in bulk than common air: makes a precipitation in lime-water; and has the general properties of the calcareous.

Genus 15.

ADUST AIR.

Common air is converted into this air by paſſing thro fire, tho there ſhould be no noxious matter, as commonly reckoned noxious, in the fuel, or in the veſſel in which it is contained. It is leſs in bulk than common air: ſuffers only a limited diminution of its bulk: makes a precipitation in lime-water, &c.

SUBDIVIS. II.

SALUTARY FACTITIOUS AIR.

Factitious air, which, when pure in its kind, is fit for the ſupport of animal life, and vegetable life, and flame.

Genus 1.

SALPETROUS AIR.

Air with the properties of common air obtained by the application of fire to ſaltpetre.

Genus 2.

SEDATIVE AIR

Is air with the properties of common air got from ſedative ſalt by fire.

Genus 3.

VITRIOLCUPREOUS AIR.

When fire is applied to the vitriolic acid and copper, this air may be produced; which has the properties of common air.

Genus 4.

SOLMINIUM AIR.

This air has the properties of common air, and is produced by the application of the ſun's rays in the focus of a burning-glaſs to minium or red lead.

Genus 5.

MERCURIAL AIR.

Of the ſame nature with the laſt, and produced, in the ſame manner, from mercury that has been calcined.

Genus 6.

VITRIOLMINIUM AIR

Is obtained by the application of pure vitriolic acid, and fire, to good minium; from 48 pennyweight of which, 36 cubic inches of this air may be obtained; the weight of which is about the hundredth part of the weight of the minium. The ſalutary quality of this air is four or five times greater than that of common air of the ſame bulk.

Genus 7.

NITRO-IGNEOUS AIR.

Air produced by the application of ſpirit of nitre and fire to minium, flowers of zinc, chalk, clay, gypſum, magneſia, wood-aſhes, flints, Muſcovy-talk. From about one cubic inch of flowers of zinc moiſtened with ſpirit of nitre, and to which a very gentle fire is applied, about three Engliſh pints of this air may be obtained. The ſalutary quality of this air is five or ſix times greater than that of common air.

There are other methods of producing ſalutary air beſide thoſe enumerated. The other properties of air are explained in pneumatics.

CLASS VII.

FIRE.

Particles of matter extremely ſubtile which give the ſenſations of heat, and light, ſeparately, or in conjunction; which ſometimes are in a fixed, and ſometimes in a moving, ſtate; and the effects of which are different according to the nature of the bodies in which they are fixed, and by which they are ſurrounded when decompoſed.

OF THE KINGDOMS OF NATURE.

Beſides the above arrangement, all terreſtrial bodies are divided into foſſils, vegetables, and animals; which are conſidered as three kingdoms in the material empire of God.

Foſſils are bodies which have not organized parts properly ſo called; which are not produced by ſeeds; which are without nerves and without ſenſation; which are commonly found on the external, or internal parts of the earth; and which are compoſed of certain ſecondary particles according to their claſſes, orders, diviſions, ſub-diviſions, genera, and ſpecies.

Vegetables are bodies which have organized parts; which propogate their kinds; which grow to maturity; decline; and rot; which have no nerves, and give no marks of ſenſation; which are compoſed of the vegetable particles above deſcribed; and which are commonly found on the ſurface of the earth, or in the waters, Animals are bodies which have organized parts, which have nerves, and give marks of ſenſation; which almoſt always have a loco-motive power; which propagate their kinds; which paſs thro infancy, maturity, old age, and die; which are found on the earth, in the air, or in the water: and the particles of which are diſtinguiſhed by certain characters from the other two kingdoms.

SECT. VIII.

OF CORPUSCULAR ATTRACTION.

PROP. I.

There is an attraction among the particles of the ſame fluid as among the particles of water, of oil, of quickſilver, of melted lead, &c.

PROP. II.

There is an attraction among the particles of the ſame ſolid, as among the particles of lead, of marble, of wood, &c.

PROP. III.

There is an attraction between the particles of ſome ſolid and fluid, and of ſome hard and ſoft bodies; as between water and wood, water and earth, water and ſponge, oil and glaſs, water and glaſs, &c.

PROP. IV.

In capillary tubes the height to which the ſame fluid will riſe, and be ſuſpended, is reciprocally as the diameters of the tubes.

PROP. V.

If a veſſel of any ſhape or ſize has its upper part drawn into a capillary tube; if it is filled with water, and inverted in a baſon of water placed in the air, or in vacuo, the whole quantity of water inverted will be ſuſpended in the veſſel and tube, provided the height of both does not exceed the height from the ſurface of the water in the baſon, to which a capillary of the ſame diameter would raiſe it.

PROP. VI.

Corpuſcular attraction is mutual among the attracting particles. It reaches only to a ſmall diſtance. It acts according to the ſurfaces of cohering bodies, and not according to their quantities of matter. And it ſeems to decreaſe in more than a duplicate ratio of the increaſe of the diſtance; but in many caſes it is difficult to aſcertain the law of this attraction.

SECT. IX.

OF ELECTIVE ATTRACTION.

PROP. I.

There is an elective attraction, or corpuſcular affinity, among the particles of matter; either abſolute, when a given body is attracted by ſome bodies, and not at all by others; or in degree only, when a given body is attracted by ſeveral others, but more readily and more ſtrongly by one than by another.

PROP. II.

If two bodies attract each other they will unite, and together form a mixt or compound.

PROP. III.

When a given body is attracted by ſeveral bodies, without any difference among them in degree, any number of ſuch may be united with it at the ſame time; but in many caſes, tho a body may be united with ſeveral others, it can be united but with one of them at the ſame time.

PROP. IV.

Two bodies which do not attract each other, may be united together by the interpoſition of a third body which attracts them both.

PROP. V.

Bodies which unite together loſe, by their union, moſt of the properties they had when ſeparate; and the compounds formed, have rather new properties, than thoſe of the bodies which are their principles.

PROP. VI.

If a mixt conſiſts of two parts, and a third body is applied to it, which attracts one of its parts and not the other; and at the ſame time attracts that part more ſtrongly than they do each other, a decompoſition will enſue, the parts of the mixt will be ſeparated from each other, and one of them will form a new mixt with the body applied: or if a mixt conſiſts of two parts, and a third body is applied to it, which, tho it may be united with either of the parts, is however more ſtrongly attracted by one of them than by the other, while at the ſame time it attracts that part more ſtrongly than the parts do each other; in this caſe too, if the condition in Prop. III. takes place, a decompoſition of the mixt will enſue, and a new compound will be formed of one part of the mixt, and of the body applied.

PROP. VII.

A body which of itſelf cannot decompoſe a mixt conſiſting of two ſubſtances, becauſe of the ſtronger attraction between them, may become capable of ſeparating them, if when it is applied to them, it is itſelf combined with another body, having a force of attraction towards one part of the mixt ſufficient to compenſate its own want thereof towards the other.

In ſuch caſes, a double decompoſition, and a double combination, enſue.

SECT. X.

OF THE COHESION OF BODIES.

PROP. I.

The coheſion of fluids, rain-water being the ſtandard, and 56 the degree of heat, is, at a medium, as follows.

Alcohol.	16	Cow's milk.	38
Oil of Olives.	20	Rain-water.	50
Oil of Saſſafras.	21	Sea-water.	56
Oil of Vitriol.	34	Quickſilver.	64
Ale.	36	&c.	

PROP. II.

The abſolute coheſion of flexible cylindric ſolids of one tenth of an inch in diameter is, at a medium, as follows.

	℔		℔
Raw Lint.	37	Raw Hemp.	46
Horſe-hair.	45	Raw Silk.	53½ &c.

PROP. III.

The abſolute coheſion of cylindric pieces of wood of one tenth of an inch in diameter is, at a medium, as follows.

	℔		℔
Fir.	23	Oak.	48
Elm.	35	Beech.	50
Alder.	40	Aſh.	50, &c.

PROP. IV.

The abſolute coheſion of cylindric pieces of metal of one tenth of an inch in diameter is, at a medium, as follows.

	℔		℔
Zinc mixed	18	Braſs	360
Lead	29¼	Silver	370
Tin	40½	Iron	450
Copper	299	Gold	500

Of the uſefulneſs of ſuch experiments; and of the variations which take place in making them.

SECT. XI.

OF CORPUSCULAR REPULSION.

PROP. I.

There is a repulſion between the particles of certain different fluids; as between water and oil, water and metals in fuſion, &c.

PROP. II.

There is a repulſion between the particles of certain different ſolids; as between the ſurfaces of poliſhed pieces of ſteel; or between the ſurfaces of convex glaſſes, &c.

PROP. III.

There is a repulſion between the particles of certain ſolids and fluids; as between camels hair and water; poliſhed ſteel and water, &c.

PROP. IV.

There is a repulſion among the particles of the ſame fluid; as among the particles of common air; or among the particles of water; or of mercury; when in a certain temperature.

PROP. V.

There is a repulſion among the particles of the ſame ſolid; as among the particles of metal when heated; and among the internal particles of glaſs-tears, or Prince Rupert's drops, &c.

PROP. VI.

Corpuſcular repulſions ſeem to take place as ſoon as the particles are without the ſphere of their mutual attraction: to reach only to a ſmall diſtance: and to decreaſe in more than a duplicate ratio of their diſtance from the limits of that attraction.

Of the theories of corpuſcular attraction, elective attraction, coheſion, and corpuſcular repulſion.

SECT. XII.

OF FIRE.

OF THE SENSATIONS PRODUCED BY FIRE.

PROP. I.

The action of fire, when in a certain quantity, excites the ſenſation of heat; and the diminution of that action, the ſenſation of cold. By increaſing or diminiſhing the quantity, theſe ſenſations may be increaſed or diminiſhed in various degrees; to denote which, different words are uſed.

PROP. II.

In eſtimating heat and cold by the feeling, the judgment is according to the temperature of the parts of the human body which are applied; but if the ſame part is applied, or different parts when of the ſame temperature, the judgment is according to the denſities of the bodies to which they are applied, all circumſtances being equal.

PROP. III.

When fire moves in ſtraight lines in a certain quantity, and is modified in a particular manner, it gives the ſenſation of light. And as there may be heat and no ſenſible light, ſo there may be light and no ſenſible heat.

OF THE ATTRACTION OF FIRE.

PROP. IV.

Bodies expoſed to heating and cooling mediums gain or loſe, in equal times, quantities of fire proportioned to the temperature in the hotter body.

Cor. 1. When the exceſs is conſtant, equal quantities are gained or loſt in equal times.

Cor. 2. There is, after a certain time, the ſame heat; that is, power of exciting heat, in an air-pump vacuum, and in the adjoining air, water, wood, and metals.

PROP. V.

The more remote a cold body is from a hot one, the leſs it is heated; and that in the duplicate ratio of the diſtance.

PROP. VI.

Bodies of the ſame kind of matter receive fire, or are heated, in proportion to their ſurfaces, all circumſtances being equal; and they retain it, or cool, in proportion to their quantities of matter.

PROP. VII.

Metallic bodies, by being reduced to a calx by fire, are increaſed in their weight.

In an open veſſel, one hundred pounds of lead, when calcined in a furnace, is increaſed to an hundred and ten pounds. One pound of zinc acquires two drams and an half. Biſmuth is increaſed one fortieth and eight part. And tin, one twelfth.

In a cloſe veſſel, an ounce of tin calcined in the furnace acquires four grains and an half: an ounce of copper, forty-nine grains: and an ounce of antimony, two drams.

In the focus of a burning-glaſs, one pound of regulus of antimony, when calcined, acquires a tenth part more; and a ſimilar effect is produced upon many other metallic bodies.

PROP. VIII.

If a metal is diſſolved in an acid, the mixture is heavier than the ſum of the weights of the metal and acid. Or if a metal is diſſolved in an acid, and precipitated by a cauſtic fixed alkali, the calx is heavier than the metal.

OF THE ELECTIVE ATTRACTION OF FIRE.

PROP. IX.

Many bodies, tho of the ſame temperature, of the ſame bulk, of the ſame ſhape, and equally expoſed to the ſame degree of fire, do not attract equal quantities of it in the ſame time: as, for inſtance, the different kinds of woods: and metals compared to wood, and to one another.

The celerity with which the following fluids attract fire is according to this order: air, mercury, petroleum, oil of turpentine, alcohol, ſpirit of wine, vinegar, oil of viriol, water, animal juice, white wine, milk, ſalt-water, aqua fortis, lintſeed oil, olive oil.

PROP. X.

All circumſtances being equal, this is the order in which the following bodies are deprived of their fire, or cool: air, mercury, alcohol, oil of turpentine, water, petroleum, oil of vitriol.

PROP. XI.

Bodies of the ſame kind, but of different colours, attract different degrees of fire in the ſame time, and in this order: black, purple, blue, green, yellow, red, white; the firſt being moſt heated.

Cor. Hence the effect of colour in utenſils, cloaths, and garden-walls.

PROP. XII.

If a porcelain cup be filled with water, and fixed in the mouth of a metallic veſſel, which is likewiſe filled with water, and made to boil upon the fire; the heat of the water in the veſſel will be greater than that in the cup. If, inſtead of the porcelain cup, different metallic ones are uſed, the heat of the water in the cups will ſtill be leſs than that in the veſſel, tho not in the ſame proportion.

Cor. Hence various methods of preventing the communication of fire to adjoining veſſels, and of regulating its temperature.

PROP. XIII.

The ſun's rays, collected in a great quantity, will inflame combuſtible matter placed in water, while the water will acquire a ſmall degree of heat.

PROP. XIV.

If maſſes of metals, earths, woods, or fluids in veſſels, are encloſed in wrappers of wool, cloth, ſkins, hair, or feathers, their heat will be preſerved much longer than if they were encloſed by air, or water, to the ſame extent with theſe wrappers.

Cor. Hence the effect of covering up ſnow, ice, plants; and of cloathing of different kinds to animal bodies.

PROP. XV.

Hot water cools ſooner in vacuo than in the air, hot iron more ſlowly. Chalk is ſlow in heating, and loſes its heat very ſoon.

PROP. XVI.

A body which attracts fire ſlowly, or in a ſmall quantity, may be made to attract it quickly, and in a large quantity, by its union with a third body.

OF THE REPULSION OF FIRE.

PROP. XVII.

Fire is repelled by certain bodies; by ſuch, for inſtance, as are very white, and by poliſhed metals; and it ſometimes has fits of attraction and repulſion among the particles of the ſame body.

OF THE EXPANSION OF FLUIDS BY FIRE.

PROP. XVIII.

All fluids are dilated by fire, but the dilatation is not according to their denſities or coheſions. Perhaps it is in a ratio compounded of both, and of their elective attractions. The following fluids dilate, and contract with different degrees of celerity, according to the order in which they ſtand: Air, mercury, alcohol, oil of turpentine, water, petroleum, oil of vitriol.

PROP. XIX.

As ſoon as a fluid is made to boil, it is, if in the open air, in the ſtate of its greateſt expanſion.

PROP. XX.

Bodies, when in a fluid ſtate, are in general, leſs denſe than when in a ſolid. But frozen water is not commonly ſo, on account of the air with which it is mixed. The force with which it expands is ſo prodigious, as to overcome the coheſion of the ſtrongeſt iron veſſels; and to raiſe up the greateſt maſs of building.

Cor. Hence the deſtructive effects of water lodged in trees, walls, or rocks, during a great froſt, even in temperate climates.

PROP. XXI.

From the degree of heat at which water freezes, to the degree at which it boils, the following bodies are increaſed in bulk in this proportion: lintſeed oil, ſeventy-two parts of a thouſand; ſpirit of wine, eighty-ſeven; and mercury, fourteen.

PROP. XXII.

Water increaſes in bulk one eighty-fifth part, from the degree of heat at which it freezes, to the degree of heat at which it boils. Alcohol increaſes one ninth part from the degree of heat at which water frezees, to the degree of heat at which alcohol boils. Mercury increaſes four parts of fifty-one from the degree of heat at which water freezes, to the degree of heat at which mercury boils. And mercury is leſſened in bulk one tenth part from its boiling to its freezing point.

OF THE EXPANSION OF SOLIDS BY FIRE.

PROP. XXIII.

Solid bodies are dilated by fire, and not in the direct ratio of their denſities, nor the inverſe of their coheſions.

Cor. Hence, and from Prop. IV. if a fluid is put into a glaſs tube, the fluid will ſink when the tube is firſt immerſed in hot water.

A Table of the expanſion of ſome metals, ſhewing how much a foot in length in each, grows longer by an increaſe of heat correſponding to 180°, expreſſed in parts, the unit of which is equal to the 10,000th part of an inch.

Barometer Tube	100	Braſs wire	232
Hard Steel	147	Speculum metal	232
Iron	151	Fine pewter	274
Biſmuth	167	Zinc hammered	323
Copper hammered	204	Lead	344
Caſt Braſs	225	Zinc or Spelter	353

Of the variations in making ſuch experiments, owing to the different degrees of purity, or to the hammering of the metals.

PROP. XXIV.

Foſſil bodies, upon the firſt application of fire dilate with fits of ſlowneſs and quickneſs; but afterwards more and more ſlowly, till they arrive at the higheſt degree of expanſion.

PROP. XXV.

Vegetable bodies are contracted by fire, in various degrees, according to the water, or reſins, which they contain. Some contract very little if cut longitudinally; but are apt to warp, unleſs in large maſſes, or ſecured from moiſture.

PROP. XXVI.

Some animal ſubſtances are contracted by fire; but others, ſuch as ivory, whalebone, hartſhorn, oxhorn, cat-gut, ſilk-ſtrings, dilate, or contract, and unequally, according to a variety of circumſtances.

Of the cracking or ſplitting of bodies by fire.

PROP. XXVII.

Common iron, but not fine ſteel, when fully liquified, is more denſe than when ſolid; as ſoon, however, as it is ſolid, it decreaſes in denſity, till it is cold.

OF THERMOMETERS.

Of the conſtruction, advantages, and diſadvantages of the air-thermometer; of the thermometer made by the Florentine Academy; by the Royal Society; by the Academy of Sciences; by Newton; by Fahrenheit; by Reaumur; by De L'Iſle; and by others.

PROP. XXVIII.

In Fahrenheit's thermometer, the freezing of water is marked 32: the boiling of water in the mean weight of the air, 212: human heat, 96: the boiling of mercury, 600: the cold produced by a common mixture of ſnow and ſal amoniac, 0:

the greateſt artificial cold which Fahrenheit was able to produce, 40 below 0: the cold at which, of late years, by an artificial mixture, the freezing of mercury began was about 350 below 0; and the mean term of congelation, 568.

PROP. XXIX.

In Newton's thermometer, 0 correſponds to 32 in Fahrenheit's, and 34 to 212; which degrees are ſubdivided into minuter parts. In Reaumeur's thermometer, 0 correſponds to 32 in Fahrenheit's; 80 to 212; 250 above 0 to 600; and 187 below 0, to 390. In De L'Iſle's thermometer, 0 correſponds to 212 above 0; about 152 below 0, to 32 above 0; 328 above 0, to 600 above 0; 469 below 0, to about 350 below 0; and 500 below 0, to 390 below 0.

When degrees of heat are mentioned in this book, Fahrenheit's ſcale is to be underſtood.

OF PYROMETERS.

Of the conſtruction, advantages, and diſadvantages of the ſimple pyrometer; of the lever pyrometer; of the pyrometer made by M. Graham, Muſchenbroek, Ellicot, Smeaton, and others.

OF FUSION.

A table of the degrees of heat at which fuſion is produced in ſome bodies.

Tin	at	408°	Regulus Martis	805°
Lead		504	Iron	869
Biſmuth		460	Olive Oil	36

Honey	104°	Fat of Fowls	68°
Pitch	186	Fat of Vipers	96
Reſins	240	Fat of Veal	100
Sulphur	244	Fat of Bullocks	104
Bitumen	300	Fat of Sheep	124
CommonButter	88	Bees Wax	140
Fat of Ducks	80	Sperma Ceti	180

Of the variations which take place in making ſuch experiments, and of their uſe.

PROP. XXX.

A compoſition of lead, zinc, and biſmuth, in equal parts, may be kept in fuſion, when they have a degree of heat which will not ſinge paper. A compoſition of one part of lead, four parts of tin, and five of biſmuth, will melt at 246 degrees. And a mixture of lead, tin, biſmuth, and mercury; their proportions being as two, three, five, and one eight part; will melt with a heat leſs than that of boiling water.

PROP. XXXI.

The particles produced by flints ſtriking againſt ſteel are commonly ſlices of the metal which are ſhrivelled up, or fuſed, or vitrified.

PROP. XXXII.

Some bodies cannot be reduced to fuſion by furnace-fire, or with difficulty; but if another body is added to them, they may be eaſily fuſed.

PROP. XXXIII.

After ſome bodies are brought into fuſion, they are capable of having their heat increaſed in different degrees, till they are fully ſaturated with the fire; and then they have a white heat, which commonly is not diſtinctly ſeen in twilight, till the degree of heat is 884.

PROP. XXXIV.

By collecting the rays of the ſun, heat has been increaſed ſo as to produce the following effects. Clay, ſand, marble, jaſper, porphyry, fireſtone, crucibles, flints, animal bodies, and pumice-ſtone were melted into glaſs. Gems became friable. Gold was vitrified, or diſſipated into ſmoke. Aſbeſtus was turned into a yellow ſlag. Copper ore was turned into glaſs in eight ſeconds. A piece of Roman patera began to melt in three. And in fifty, a piece of the Alexandrian pillar was fully vitrified.

OF THE EVAPORATION OF BODIES.

PROP. XXXV.

The particles of all bodies, when in open veſſels, are diſſipated by the application of fire in a certain quantity. A ſmall degree of heat produces this in ſome, while the greateſt is neceſſary to produce it in others.

PROP. XXXVI.

If a veſſel of water is placed where the air has but little motion, and its heat is 60°, it will evaporate about eight inches of its depth in one year; and if it is kept at the ſame degree of heat with that of the air in a hot day in ſummer, it will evaporate about the ſixtieth part of an inch of its depth in two hours. If it is expoſed to a ſtrong wind, it will evaporate much more.

OF BOILING.

PROP. XXXVII.

All fluids, excepting air, that are homogeneous, and that exhale without any ſeparation of their parts, may be made to boil by fire, and then they are as hot as they can be in the open air; but by confining the ſteam, the heat may be increaſed prodigiouſly; and the water will receive greater or leſs degrees of heat before it boils, according to the weight of the ſuperincumbent atmoſphere.

PROP. XXXVIII.

While the air is of a mean weight, ether will boil at about 100 degrees of heat; alcohol at 176; water at 212; ſpirit of nitre at 242; lixivium of tartar at 240; oil of vitriol at 546; lintſeed oil and quickſilver at about 600.

OF THE BURNING OF BODIES.

Of ſmoke, of flame, of calx, and of the decompoſition of bodies by burning.

OF EXCITING HEAT IN BODIES.

By the following methods fire is excited in bodies; and, conſequently, heat in various degrees.

PROP. XXXIX.

By mixing the vitriolic acid with water in a certain temperature, with alcohol, vinegar, calcareous earth, pit-coal, ſal gem, ſal amoniac, oil of aniſeed, &c.: by mixing the ſpirit of nitre with lead, tin, iron, copper, braſs, &c.: aqua-fortis with alcohol, ſpirit of ſal amoniac, alum, borax, &c.: the muriatic acid with iron, copper, tin, bone-earth, &c.: the vegetable acid, with ſalt of tartar, calcareous earth, &c.: water, with acid of vitriol, and iron: water with quicklime: and by agitating oils in common air.

If ſpiritus fumans nitri is added to any of the following bodies, there will be an effervеſcence and flame; oil of caraways, ſaſſafras, guiacum, camphor, pepper, cornu-cervi, cranium humanum, ungulae, &c.

If two parts of aqua fortis, and one of oil of vitriol, are mixed together, and poured into an equal bulk of oil of turpentine, the mixture will kindle into a flame.

If large and equal quantities of ſteel-filings, and powder of ſulphur are made into a paſte with water, they will, after ſome time, break out into a flame, though covered up with earth.

PROP. XL.

Heat is produced by vegetable bodies while they undergo the vinous fermentation; and by animal and vegetable bodies while they undergo the putrefactive fermentation.

PROP. XLI.

By attrition, heat and ſometimes flame are produced; as by the rubbing of ſticks, ropes, &c.: and by the friction of the parts of large machines, when a fluid is not interpoſed.

PROP. XLII.

Heat is produced by percuſſion, as by hammering a ſmall piece of iron, if it makes part of a large maſs; and by colliſion, as by the ſtriking of flint againſt ſteel.

PROP. XLIII.

Heat and fire are produced by expoſing phoſphorus to common air.

PROP. XLIV.

By an aſſemblage of the ſun's rays, a fire may be produced which will diſſipate the moſt firm, and the leaſt inflammable bodies: and yet the power which the rays have to produce ſuch effects increaſes in ſo high a ratio, that their heat at a ſmall diſtance from the focus, does not equal that of boiling water.

Cor. Hence the effect of contracting the flame of a blow-pipe, and of a furnace.

OF GENERATING COLD IN BODIES.

PROP. XLV.

By the following methods bodies are robbed of their fire; and, conſequently, cold is produced, in various degrees.

By mixing the vitriolic acid greatly diluted, with nitre in a certain proportion, or with the volatile ſal urinae: by mixing aqua fortis with ſal amoniac: ſpirit of ſea ſalt with antimony: the acetous acid with all volatile alkaline ſalts: alcohol with ſal amoniac, and almoſt all eſſential oils: water with nitre, borax, ſea ſalt, blue vitriol, rock-alum, ſal amoniac, &c.

PROP. XLVI.

If a veſſel containing water be ſet in ſnow or pounded ice, with which is mingled common ſalt, ſal amoniac, &c. as the ſnow or ice melts away, the water will freeze in the veſſel. Or if the whole be ſet upon the fire, as the ſalt and ſnow grow liquid by the heat, the ſame effect will follow.

PROP. XLVII.

A great degree of cold, even to 40° below freezing, will be produced, if ſpirit of nitre, or oil of vitriol, be mixed with ſnow or pounded ice. If the ice ſo produced be mixed with the ſtrongeſt ſpirit of nitre, which has been cooled artificially, and if the ſame operation be often repeated, when the heat of the air is not greater than 2° above 0, the cold of the mixture will be increaſed to ſuch a degree, as to freeze the mercury in the thermometer. The greater the cold of the air, the better does the experiment ſucceed. When it was very great, the artificial cold produced in this manner, was, it is ſaid, between 1500° and 1600° below 0.

PROP. XLVIII.

If a bottle of water, or wine, or ſpirit, &c. has its outſide moiſtened with water from time to time, and is placed in a current of air, cold will be generated in the bottle while the moiſture on its outſide is carried off by the air; and very intenſe cold may be produced, in a ſimilar manner, by the evaporation of volatile fluids, ſuch as wine, brandy, alcohol, &c.

Cor. Hence liquors and animal bodies may be cooled very much in the hotteſt weather; and ice may be produced.

OF LATENT OR IMBIBED FIRE.

PROP. XLIX.

If a piece of ice is in a medium, which contains a greater quantity of fire than is neceſſary to melt it, the temperature of the ice will continue riſing till the ice begins to ſoften, and then its temperature will be ſtationary for about 150 times longer than the time which it took to riſe from 30 to 31 degrees. At the end of this time, the ice will be perfectly fluid, and its temperature will become progreſſive, according to Prop. IV.

If a pound of water, the temperature of which is about 32°, is poured to an equal quantity of water which is at 212°, the temperature of the mixture will be 122°: but if a pound of beaten ice is mixed with an equal quantity of water at 212°, the temperature of the mixture will be 47°.

PROP. L.

If water, at a temperature ſeveral degrees higher than 32°, is expoſed to a medium conſiderably lower; when the water arrives at that temperature in which it can no longer remain fluid, it is ſtationary for near 150 times the time ſpent in paſſing from 34 to 33 degrees. After all the water is perfectly frozen, it begins immediately to ſink in its temperature, according to Prop. IV.

If a ſolution of Glauber's ſalt is made at 180°, and kept at that temperature; if it is let cool, without being expoſed to agitation, it will cool without being cryſtallized: but if it is quickly ſhaken, it will inſtantly cryſtallize, the thermometer at the ſame time riſing ſeveral degrees.

PROP. LI.

Unboiled water, if undiſturbed, may be cooled below the freezing point, and yet remain fluid; but upon giving it a ſhake, it will freeze immediately. When boiled water in the ſame circumſtances is cooled to the freezing point, a part of it is immediately changed into ice; after which more ice is continually formed, till the whole is congealed.

PROP. LII.

If one thermometer is put into a freezing mixture, and another over it; after ſome time the firſt will ſink, and the ſecond will riſe as the freezing goes on.

By the condenſation of ſteam, heat is generated.

OF ANIMAL HEAT.

PROP. LIII.

The heat of the moſt inflammable foſſils, and of the moſt flouriſhing vegetables, is the ſame with that of the bodies which ſurround them, as explained Prop. IV.—XVII.

Moſt living inſects have but a ſmall degree of heat above the air they live in; but the heat of a ſwarm of bees is about that of the human body.

The heat of living fiſhes is in general nearly the ſame with the medium in which they ſwim. That of the cetacea is 96°.

From 100° to 108° is the vital heat of birds; and from 100° to 103°, of the common quadrupeds.

96° is the heat of a young healthy man, whoſe mind is at eaſe, and body at reſt.

There is a power in the animal frame of generating heat when cold would be deſtructive; and of generating cold when heat would be deſtructive. This power is very different in different animals. Some of them are killed by very ſmall changes of heat and cold; but man can bear very great ones: he can withſtand the cold of ſurrounding mediums; which, without this power, would ſoon freeze the fluids in his body: and he can not only enjoy life between the tropics, but live for ſome time in places heated by art many degrees above that of boiling water.

OF THE HEAT OF THE EARTH.

PROP. LIV.

There is, independent of the ſhining of the ſun, a permanent heat in the bowels of the earth and ocean; which is different from that in the air, in the waters, and in ſmall bodies on the ſurface of the earth: and this heat of the earth and ocean is not the ſame at all depths, eſpecially in the ocean.

Cor. 1. Hence the mean temperature of ſprings, or natural fountains, is different according to their heights above the level of the ſea, and the magnitude of the hills from which they flow. The water below ice is often conſiderably warmer than the ice. The cold of the upper ſurface of ſnow lying upon the ground is 0°, while the cold of the under ſurface is a little below 32°. Hence ſome ſprings flow and ſmoke during ſevere froſt; while others in their neighbourhood are frozen. Some lakes do not freeze till the winter is far advanced; and ſome do not freeze at all. Hence lava retains its heat a long time, and very unequally. And from the fluidity, tranſparency, and evaporation, of the ſea, joined to the above circumſtances, the mildeſt temperature of the ſeaſons is in iſlands and on ſea-coaſts, all circumſtances being equal.

Cor. 2. Hence animals defend themſelves againſt the coldneſs of the weather by going into the earth, or into the ſnow.

Cor. 3. Hence, in high houſes, the uppermoſt ſtory is the hotteſt in the morning, the lowermoſt is the cooleſt, and this temperature is reverſed at night: and when the chimnies are open, and without fire, there is a current of air from the rooms to the atmoſphere; and the contrary.

PROP. LV.

Tho the heat in different places on the ſurface of the earth depends ſomewhat upon the diſtance of the place from the poles, and the obliquity of the ſun's rays; yet, except in high latitudes, it depends much more upon the height of the place above the level of the ſea, the ſerenity of the ſky, the length of the day, the nature of the ſoil, ſubterraneous fires, the denſity and moiſture of of the air, the winds, the neighbouring rivers, lakes, ſeas, woods, hills, and regions covered with ſnow or ice.

PROP. LVI.

The ground, if not very moiſt, is ſeldom frozen deeper than a few feet, even in northern countries.

The air in Britain, A. D. 1768, was 2° below 0°: at Peterſburgh, A. D. 1739, 30°; and, A.D. 1759 about 42°: at Selingenſkoy it has often been 55°: at Kirengens, A. D. 1738, it was at 113°: and at Jeniſſa, A. D. 1735, it was at more than 120° below 0°.

PROP. LVII.

The ground eaſily acquires a great heat from the ſun's rays; and more or leſs according to its nature and ſituation. In many parts of Europe it has been heated to 150°; and in ſome of the inland parts of Africa, it is ſaid, to 212°, or to the heat of boiling water.

The air at St. Peterſburgh, A. D. 1734, was 98° above 0°: at Leyden, A. D. 1750, 92°: at Utrecht, A. D. 1733, 94°: at London, A. D. 1746, 85°: at Senegal 110°: at Podor, 134°.

OF THE HEAT OF THE SUN AND PLANETS.

PROP. LVIII.

As heat depends upon other circumſtances much more than upon the immediate rays of the ſun; and as we are ignorant of the nature of the matter of which the ſun and planets conſiſt, we can form no judgment of their heat; nor is the heat of the planets to be eſtimated by their diſtance from the ſun.

THE THEORY OF FIRE.

Of the different theories of fire; and a theory of it founded upon the above, and other experiments.

SECT. XIII.

COROLLARIES TO THE PRECEEDING SECTIONS.

Of combining, and decompoſing bodies by ſolution, fuſion, evaporation, precipitation, fermentation, putrefaction.

Of painting, dyeing, cementing, ſoldering, etching; and the principles of various arts.

Of the twiſting and ſhortening of ſtrings, ropes, cloths, &c. by moiſture.

Of the capillary ſyphon. Of filters of different kinds.

PROP. I.

Several liquors may be mixed together, and if filters are applied to them, the liquors may be drawn off ſeparately.

Of the riſe of ſap in vegetables, and the ſecretions in animal bodies.

Of hot ſprings, or hot natural fountains.

Of inflammable exhalations. Of ſuffocating vapours, corruſcations, and exploſions in mines and caverns.

PROP. II.

If fire is applied to ſaltpetre and ſulphur when mixed together, they will crackle, flame, or explode, according to the ſlowneſs and force with which the fire is applied.

Of gun-powder; how made, preſerved, and fired to moſt advantage.

PROP. III.

The quantity of air obtained by firing gun-powder is equal in bulk to 244 times the bulk of the gun-powder fired; when the air ſo produced is compreſſed by the atmoſphere, and reduced to the ſame heat.

Cor. If the elaſtic power of common air is increaſed four times by a heat equal to that of iron juſt beginning to grow white; and if the air from gun-powder is equally affected by heat; then in the inſtant of exploſion the expanſive force of this air is about a 1000 times greater than the preſſure of the atmoſphere.

Of rockets, fire-works, and other uſes of gun-powder.

Of pulvis fulminans, aurum fulminans, and the effects which they produce.

Of ſteam. Of the aeolopile, and the uſes to which it has been applied.

PROP. IV.

One ounce of Troy-weight of water makes 9250 cubic inches of ſteam, of equal elaſtic force with the ſame number of inches of common air; the weight of the ſteam being one-fifth part of the weight of the air; and the ſteam of one cubic inch of water being ſufficient to exclude the air out of a veſſel of 4000 inches in capacity.

Of Papin's digeſter, and the effects produced by it.

Of earthquakes, and vulcanos, and the cauſes of them.

Of configurations, and cryſtals; and the manner in which they are produced.

PROP. V.

Configurations are as various as can be imagined; but in the ſame circumſtances they are always the ſame.

PROP. VI.

The cryſtals of ſea-ſalt are cubes, many of which are pyramids, with a hollow quadrangular baſe; of nitre, parallelopipeds with ſix angles; of ſalt of laurel, partly hexangular parallelopipeds, and partly truncated pyramids; of ſalt of liquorice, double hexangular pyramids; of ſalt of white hellebore, rhombuſes; of vitriol, rhomboidals; of alum, octogonals; of lead, cubes: of tin, quadrangular pyramids; of copper, oblique angled parallelopipeds; of iron, rhomboidals; and of other bodies, other ſolids; the cryſtals of the ſame body, if completely formed, being invariably the ſame.

Of the vegetation of metals, and the reſuſcitation of plants.

Of the figures on ſlates, flints, agates, Mocha ſtones, marbles; and the method of producing them by art.

Of the forms of precious ſtones; and of columns of baſaltes, &c. found in the earth.

Of the aſcent of vapour in air, and in vacuo. Of fogs, clouds, rain, dew, hoar-froſt, ſleet, ſnow, hail, and other phenomena of air and water when mixed together.

ELECTRICITY.

SECT. I.

OF ELECTRICS AND NON-ELECTRICS.

PROP. I.

Every piece of matter is either an electric, or non-electric; or, which are ſynonymous terms, a non-conductor or conductor.

To the firſt claſs belong amber, glaſs, ſealing-wax, ſulphur, roſin, baked wood, ſilk, feathers, wool, hair, paper, leather, &c.

To the ſecond claſs belong metals, and ſemi-metals, water, flame, all fluids excepting air and oils, animal bodies, common earth, &c.

This propoſition is only true when the bodies are rubbed, &c. in the common manner. It will afterwards appear that electrics and non-electrics are convertible into each other by a different manner of rubbing, by heat, cold, &c.

SECT. II.

OF ELECTRIC MATTER.

PROP. I.

An excited non-conductor, or electriſed conductor when inſulated, is ſurrounded with a maſs of very ſubtile matter, which is the cauſe of the attraction and repulſion of light bodies, when brought near it; and the form of this matter is that of the body it ſurrounds.

PROP. II.

The particles of this electric matter eaſily pervade the moſt perfect vacuum, and the denſeſt conducting bodies.

PROP. III.

Tho electric matter be extremely ſubtile, yet it may be ſeen, if it runs off in a ſtream, or if it leaps from body to body, but not otherwiſe; and it may be heard, ſmelt, felt and taſted, if accumulated in large quantities.

Cor. Hence light is ſeen in a barometer at the top of the quickſilver when it falls; and none is ſeen when it riſes: and hence the effect of the military lantern.

PROP. IV.

Electric matter is not created by friction, but collected; being diffuſed thro all bodies.

Cor. When we would accumulate electric matter, a communication ought to be made between the rubbers and the earth, or the walls of the houſe.

PROP. V.

Fire and electric matter ſubſiſt together in the ſame body. Water extinguiſhes fire, but ſerves to collect electric matter. Freezing is not retarded by electric matter, tho accumulated in large quantities. A bar of metal may be heated at one end, while it is cold at the other; but every part of it is electrified equally.

PROP. VI.

When electric matter ſtrikes thro a body; if the body contains phlogiſton, or pure fire, in a certain quantity, the body will be dilated, or melted, or inflamed; and tho the proportion of the phlogiſton, of the pure fire, and of the electric matter ſhould be varied, the ſame effects will follow.

PROP. VII.

By the electric ſhock, the calces of metals may be reſtored to their metalline ſtate: and gold and ſilver may be calcined; ſome of the particles being converted into a tranſparent glaſs, and ſome tinged with various colours.

SECT. III.

OF THE ATTRACTION OF ELECTRIC MATTER.

PROP. I.

The particles of electric matter are ſtrongly attracted by other bodies.

PROP. II.

Tho electric matter is ſtrongly attracted by other bodies, yet it would ſeem that in its paſſage thro them, it brings none of their particles along with it; for it has the ſame acidulous phoſphorine taſte, and ſmell, whatever be the body thro which it paſſes.

Cor. Hence electric matter cannot be made a vehicle to perfumes or medicines, in the way that ſome have aſſerted.

PROP. III.

If the ſurface of a body, on which electric matter is accumulated be round, large, and ſmooth, it will continue electrified till the ſurrounding bodies attract the electric matter. If it has an edge, or angle, the electric matter will paſs off ſpeedily. If it has a ſharp point, or points, it is with difficulty that it can be electrified at all.

PROP. IV.

Pointed non-electrics ſerve to draw off, as well as to throw off, electric matter.

PROP. V.

When electric matter is drawn off by non-electric points, it is ſlowly, and without noiſe. When it is drawn off by round or blunt bodies, it is ſuddenly, and with an exploſion, or ſnap.

Cor. A great quantity of electric matter may be drawn off by a ſharp wire, without producing any ſenſible effect.

PROP. VI.

If electric matter paſſes thro a body or bodies, which are good conductors, and the parts of which are in cloſe contact with each other, its motion ſeems to be inſtantaneous, tho the diſtance be very great: but if the bodies are not good conductors, or if they are at ſome diſtance from each other, its velocity may be meaſured; and its power is diminiſhed.

PROP. VII.

An increaſe of ſurface makes a body capable of receiving a greater quantity of electric matter; and it would ſeem in proportion to the ſurface.

PROP. VIII.

Excited non-conductors, or electriſed conductors, retain their electric matter, till conductors that have leſs are brought near them; and then it is equally divided.

SECT. IV.

OF THE ELECTIVE ATTRACTION OF ELECTRIC MATTER.

PROP. I.

The following bodies attract, or conduct, electric matter according to the order in which they ſtand.

CLASS I. Iron, braſs, copper, ſilver, gold, lead.

CLASS II. Biſmuth, nickel, zinc, antimony, arſenic, cobalt.

CLASS III. Metallic ores, ſemi-metallic ores.

CLASS IV. Charcoal, water, oil of vitriol, ſpirit of wine, animal bodies, moiſt vegetables, flame.

CLASS V. Common-earth, common ſtone, glue, &c.

PROP. II.

The following bodies are placed according to their non-attracting, or non-conducting qualities; the firſt in order being the moſt perfect non-conductors.

CLASS I. Diamond, ſapphire, carbuncle, opal, amethyſt, beryl, cryſtal, glaſs, and all vitrifications.

CLASS II. Venice talc, garnets, rubies, topazes, hyacinths.

Class III. Amber, ſealing-wax, baked wood, porcelain-veſſels, ſilk, air, carnelians, reſins, ſulphur, ſalts, ſugar, pitch, gums, jett, oils, ether, marble.

Class IV. Down, wool, feathers, hair, parchment, horns, bones, whale-bone, ſhells.

Class V. Dry willow, mahogany, aſh, elm, oak, boxwood, ebony, &c.

Of the differences in the conducting, and non-conducting powers of the bodies in the above claſſes; according as they are more or leſs pure; and according to other circumſtances.

PROP. III.

When electric matter paſſes thro a body or bodies, and comes in its paſſage to a body or bodies, the conducting powers of which are different, it will run thro that body which is the moſt perfect conductor tho its courſe ſhould be much longer. But if the paſſage thro the leſs perfect conductor is very ſhort, it will ſometimes go thro the leſs perfect conductor entirely, and ſometimes divide itſelf between both. If it is to go thro a homogeneous body, or thro bodies that are equally good conductors, it will take the ſhorteſt paſſage.

Cor. 1. A man may hold a piece of metal in his hand, and a quantity of electric matter will paſs thro the metal, without his receiving the leaſt ſhock, provided the quantity is not very great, nor the piece of metal very ſmall.

Cor. 2. Hence, and from Prop. vi. Sect. iii. electric matter may be made to paſs thro caſcades, lakes, or the ocean, tho violently agitated; and hence ſpeedy intelligence may be given to perſons at a great diſtance.

SECT. V.

OF THE REPULSION OF ELECTRIC MATTER.

PROP. I.

The particles of electric matter mutually and ſtrongly repel each other.

COR. A ſmall jett of water when electrified will ſpread out into many ſtreams, or be divided and thrown about like drops of rain.

Water which only drops from a capillary tube, or from a funnel, will run in a continued ſtream, or ſtreams, when electrified; and the quantity that flows in ſtreams will be greater than that by drops in the ſame time.

If the bore of a capillary tube is ſo ſmall that water cannot drop thro it, electric matter will make it run, and in a conſtant ſtream. If the bore of a tube thro which water runs is larger than that of the largeſt capillary tube, electric matter will not increaſe the quantity that runs in a given time.

SECT. VI.

OF THE THREE STATES OF ELECTRIC MATTER.

PROP. I.

While a body is in the natural ſtate, if any light piece of conducting matter, whether inſulated or not, which is in the ſame ſtate, is brought near it, the light piece of matter will neither attract nor be attracted. If the light piece of matter is in the plus ſtate, and inſulated, it will firſt be attracted and then repelled. If in the minus ſtate, it will be attracted.

PROP. II.

If a body is in the poſitive ſtate, and the light piece of matter is in the natural ſtate, and inſulated, it will firſt be attracted and then repelled. If the light piece of matter is in the plus ſtate, it will be repelled, provided the plus ſtates are equal; if unequal, it will firſt be attracted and then repelled. If the light piece of matter is in the minus ſtate, it will be attracted and then repelled, provided the quantity received can overcome its gravity, and put it into the natural ſtate.

PROP. III.

While a body is in the negative ſtate, and the light piece of matter is in the natural ſtate, it will be attracted. If the light piece of matter is in the plus ſtate and inſulated, it will be attracted and afterwards repelled, provided the quantity given is more than ſufficient to put them both in the common ſtate, and to overcome its gravity. If it is in the minus ſtate, it will not be attracted, provided the minus ſtate of both is the ſame.

The weight of the light body, and the heat or moiſture of the ſurrounding air often diſturb theſe experiments.

PROP. IV.

Smooth glaſs rubbed in the common way exhibits the poſitive ſtate; reſins, wax, and amber, the negative. Hence the terms, vitreous, and reſinous, ſtates; vitreous, and reſinous, electric matter.

PROP. V.

When an inſulated conductor is brought near an electrified body, it acquires on the part neareſt to that body a contrary ſtate; and on the oppoſite part the ſame ſtate with that of the electrified body. As the conductor is brought nearer, each of the ſtates will increaſe till brought within the ſtriking diſtance; and then a quantity of electric matter will go off from the electrified body, and ſtriking upon the conductor, will put it throughout in the ſame ſtate.

PROP. VI.

When an electric body is brought near an electrified body, the electric body will acquire the different ſtates on different ſides. Theſe ſtates will increaſe as the diſtances decreaſe, till at laſt if ſome electric matter is communicated to the electric body, the electric body will not be throughout in one ſtate, but will often ſhew the different ſtates in different parts, and in alternate ſucceſſion.

PROP. VII.

The form of a pencil of electric matter paſſing from an electrified body in the dark is like a cone; the baſe of which is to, or from, the body, according as it is in a poſitive or negative ſtate.

SECT. VII.

OF THE LEYDEN PHIAL.

PROP. I.

At the ſame time that the wire and the inſide of the phial are electrified plus, its outſide is electrified minus; and in exact proportion.

PROP. II.

Both ſides of the phial cannot be reſtored to the ſame ſtate by inward communication or contact of the parts. It muſt be done by a communication formed without by ſome conducting body touching them both at the ſame time, or touching them alternately. In the firſt caſe both ſides are reſtored to the ſame ſtate, with the greateſt quickneſs; in the laſt caſe, by degrees.

Cor. A phial cannot be electrified that is foul or moiſt on the outſide, from the cork or wire all along to the coating.

PROP. III.

As no more electric matter can be thrown into the inſide of the phial, when all is driven from the outſide; ſo in a phial that is not electriſed, none can be thrown into the inſide, when none can eſcape from the outſide; and in a phial that is electriſed, little can be drawn from the inſide, unleſs an equal quantity can at the ſame time get in at the outſide.

PROP. IV.

The ſhock to the nerves of the perſon who holds the phial, and touches the wire, is produced by the ſudden paſſing of the electric matter thro his body, in its way from the inſide to the outſide of the phial; or by its acting upon the electric matter contained in his body.

PROP. V.

A phial may be electrified thro the coating as well as thro the wire; and there will be the ſame exploſion and ſhock to the nerves, if the electrified phial is held in one hand by the wire, and the coating is touched by the other, as when held by the coating and touched by the wire. But a phial electrified thro the wire, will give the exploſion thro the wire: and one electrified thro the coating, will give the exploſion thro the coating, and in no other way.

PROP. VI.

A Leyden phial cannot be charged if there is the leaſt crack or fiſſure in the glaſs, or if any part of it is not vitrified.

PROP. VII.

The whole force of the phial, and power of giving a ſhock, is in the glaſs itſelf; the conductors in contact with the two ſurfaces ſerving only to give to, and receive from, its ſeveral parts.

COR. 1. Hence, and from Prop. VII. Sect. III. it is not the abſolute quantity of non-conducting matter contained within the phial; but, all things being equal, the quantity of its ſurface that makes it capable of giving a greater ſhock.

Cor. 2. The properties of the Leyden phial may be given to a pane of glaſs, or to a plate of roſin, by coating it, and by accumulating electric matter upon one of its ſides, in the ſame manner as upon the ſide of the Leyden phial: and a quantity of air may be made to give a ſhock in like manner.

Cor. 3. The phial will retain its charge a long time, if placed in dry air; or if its wire is covered by a non-conducting body.

SECT. VIII.

OF ELECTRIC MACHINES.

Of the different methods of fitting up and exciting glaſs globes, glaſs cylinders, glaſs plates, and baked wood.

Of prime-conductors, and the manner of inſulating bodies to moſt advantage.

Of compoſitions of equal parts of roſin, ſhell-lac, and ſulphur; of two parts of ſhell-lac, and one of Venice turpentine, &c. with the beſt way of exciting them.

Of jars and batteries; and the beſt method of giving ſhocks, or of ſending great quantities of electric matter thro bodies.

Of electrometers made of a ſingle thread; of a thread and ball; of a thread, ball, and glaſs-ſemicircle; of a thread and two balls; of a quadrant and radius; of a diſcharger at different diſtances, &c.

SECT. IX.

OF THE COHESION OF BODIES BY ELECTRIC MATTER.

PROP. I.

If two panes of glaſs are applied to each other, if their external ſides are coated, and if the one is electrified plus and the other minus, there will be a ſtrong coheſion between them.

PROP. II.

White or black pieces of ſilk, when excited, adhere to bodies with broad ſmooth ſurfaces, tho ſuch bodies ſhould not be electrified.

PROP. III.

Two pieces of ſilk, one white and another black, when excited and brought together, will adhere together, and ſometimes with a force that will require many times their own weight to ſeparate them.

SECT. X.

OF ELECTRIC AND NON-ELECTRIC BODIES, WHEN NOT RUBBED IN THE COMMON MANNER.

PROP. I.

Cloth, flannel, wool, ſilk with or without oil, and leather with or without chalk, greaſe, amalgam, &c. have very different effects upon the beſt electrics; ſo that according to the rubber, the body will appear to be an electric or non-electric.

PROP. II.

The following non-electrics may be excited like electrics, tho not ſo ſtrongly; if inſulated and rubbed gently againſt wool, or ſoft black ſilk.

Iron, ſilver, gold, tin, lead, copper, braſs, &c.

Marble, pebbles, agate, gypſum, dried earth, unglazed earthen ware, &c.

Pepper, cinamon, cloves, mace, garlic, onions, carrots, turnips, potatoes, beans, peas, oranges, apples, cane, leaves of vegetables, &c.

Ivory, bone, horn, ſhells of fiſhes and fowls, parchment, catgut, tallow, &c.

SECT. XI.

OF ELECTRICS AND NON-ELECTRICS, ACCORDING TO THEIR TEMPERATURE, AND THE TEXTURE OF THEIR PARTS.

PROP. I.

Amber, glaſs, wax, roſin, ſulphur, wood, air, &c. when made very hot, become conductors; and by varying their temperature, they change from the conducting to the non-conducting ſtate.

Cor. Hence an electric machine cannot be excited, and the Leyden phial will not give a ſhock, when they are much heated.

PROP. II.

If water is converted into ice in a ſmall degree of cold, the ice will conduct; if in a great degree, it will not conduct. The conducting power of charcoal is different according to the heat employed in making it; that which was made with the greateſt heat being the moſt perfect conductor.

PROP. III.

The ſurfaces of new glaſs tubes often conduct electric matter, but after ſome time loſe that property. If they are made red-hot, they recover it again, and loſe it as before.

Cor. 1. Hence electric machines become good by uſe, tho they could not be excited at firſt.

Cor. 2. Tho electric matter commonly paſſes thro the ſubſtance of conducting bodies, yet it ſometimes paſſes over their ſurfaces.

PROP. IV.

Free ſtone, baked clay, &c. have conducting and non-conducting fits, according to their temperature from 32° of heat to 250°.

PROP. V.

Some conductors, ſuch as ſtone and brick, become non-conductors, when reduced to a fine dry powder: but the minuteſt filings of metals are always conductors.

PROP. VI.

Metallic calces, and the ruſt of metals, are non-conductors; and ſome animal and vegetable ſolids when reduced to aſhes.

SECT. XII.

OF CHANGING THE STATES OF ELECTRIC MATTER BY CHANGING THE SURFACE OF THE BODY OR OF THE RUBBER.

PROP. I.

Vitreous bodies with ſmooth ſurfaces, when rubbed in the common manner, are in the plus ſtate; and vitreous bodies with rough ſurfaces are in the minus.

PROP. II.

If the poliſh is taken off part of a glaſs tube, the plus and minus ſtates may be produced by the ſame ſtroke of the ſame rubber; and if ſmoothneſs is reſtored to the unpoliſhed part by chalk, &c. the whole tube will electrify plus as if the poliſh had never been taken off it.

PROP. III.

White ſilk, when excited, electrifies plus, and black ſilk electrifies minus.

PROP. IV.

A globe of ſealing wax, and a globe of glaſs with a ſmooth ſurface, communicating with each other, cannot be excited; if the rubbing of both, and if all circumſtances are equal.

PROP. V.

Sealing wax may be electrified plus by rubbing it with quickſilver or tinfoil. A ſmooth glaſs tube may be electrified minus by rubbing it acroſs a cat's back, or with a rabbit's ſkin. Amber may be electrified plus by a blaſt of air. Two pieces of plate-glaſs may be excited by rubbing them gently againſt each other, and the one will be poſitive, the other negative. Almoſt all electrics will acquire either ſtate at pleaſure by uſing proper rubbers; and the rubbers are always in a contrary ſtate to that of the body rubbed.

SECT. XIII.

OF ELECTRIFYING BODIES BY HEAT WITHOUT RUBBING THEM.

PROP. I.

The lapis tourmalenſis may have each of its ſides, or both of them at once, made poſitive by friction; but it may be excited by heat without any friction; and one of its ſides C, will be in the plus ſtate, while the other ſide D, will be in the minus. A ſmall degree of heat will ſometimes produce this appearance; but it may eaſily be effected by plunging the tourmalin in hot water, and drying it afterwards.

PROP. II.

The tourmalin, not being electrical, will become ſo by cooling; but with this difference, that the ſide C will be in the negative ſtate, and the ſide D in the poſitive.

PROP. III.

If the tourmalin, in a non-excited ſtate, be heated equally, and ſuffered to cool without either of its ſides being touched, C will be poſitive, and D negative, the whole time of the increaſe and decreaſe of its heat. But if the heat is not equally diffuſed, as by the ſudden approach of a hot iron, the above appearances will vary.

PROP. IV.

If one piece is cut from the poſitive end of the tourmalin, and another from the negative end, the pieces will have the ſame properties which they had before they were cut off. But the oppoſite ſides of each piece will be plus and minus, according to the general property of the tourmalin; and the remaining part will have the ſame properties which it had when entire.

PROP. V.

The moſt of theſe qualities belong to the Braſil topaz, and to ſome other precious ſtones.

PROP. VI.

If a thin glaſs ball has electric matter thrown into it, and is hermetically ſealed, it may be excited by heat alone; and air may be electrified plus and minus by changing its temperature.

PROP. VII.

Melted wax poured into a veſſel of glaſs or wood, is electrified negatively; and the glaſs or wood, is electrified poſitively.

PROP. VIII.

Chocolate becomes highly electrified by cooling in the tin-pans in which it is made. It ceaſes to be ſo by handling; but if melted again it will be electrified as before, eſpecially if oil is added to it.

PROP. IX.

Sulphur is ſtrongly excited, if melted in an earthen veſſel, and left to cool upon conductors; but it is not excited if left to cool upon electrics. If it is melted in a glaſs veſſel, the ſulphur will be negative, and the glaſs poſitive, whether they are left to cool upon electrics or non-electrics. If it is poured into a veſſel of baked wood, it will become negative, and the wood poſitive; but if into ſulphur, or rough glaſs, it will not be excited at all. If it is poured into a metal cup, and there left to cool, it will not be excited till they are ſeparated; and then it will be plus, and the cup will be minus.

SECT. XIV.

OF THE ELECTRIFYING QUALITIES OF SOME ANIMALS.

PROP. I.

The hair upon the heads of moſt infants, and upon ſome grown perſons, may be ſtrongly excited by friction. In the ſame manner, a quantity of electric matter may be produced from a cat's back, that will inflame ardent ſpirits. A ſimilar property, in ſome degree, belongs to ſome other animals.

PROP. II.

The torpedo, anguilla tremula, gymnotus, &c. have the power of giving ſhocks, which are communicated and intercepted by the conductors and non-conductors of electric matter.

It would ſeem that theſe animals can collect electric matter in the plus and minus ſtates upon the different ſides of their bodies; and then diſcharge it, like the Leyden phial, in order to deſtroy their prey, or to annoy their enemies; but ſome things relating to this power require farther inveſtigation.

SECT. XV.

OF ELECTRIFYING MAGNETS AND IRON.

PROP. I.

Electric matter and magnetic matter may ſubſiſt together in the ſame body. The accumulation of electric matter affects not the ſtrength of the magnet in ſuſtaining weights, or in acting upon needles, allowance being made for the attractive and repulſive power of electric matter when acting upon light bodies, as explained in Sect. III.

PROP. II.

A ſtrong electric ſhock frequently gives polarity to needles. If the needle, when ſtruck, lies eaſt and weſt, the end entered by the electric matter will point north. If it lies north and ſouth, the end that lay towards the north will point north, at whatever end the electric matter entered. The polarity given is ſtrongeſt when the needle lies north and ſouth, and weakeſt when it lies eaſt and weſt.

PROP. III.

By an electric ſhock the poles of a magnetic needle are ſometimes reverſed; and ſometimes the magnetic power is totally deſtroyed.

SECT. XVI.

OF ELECTRIFYING LIVING VEGETABLES AND ANIMALS.

PROP. I.

The growth of ſmall vegetables is often quickened by electrifying them plus; and the contrary effect is produced by electrifying them minus.

PROP. II.

The pulſe of animals is commonly quickened, and their perſpiration increaſed, by electrifying them plus for ſome time.

PROP. III.

Obſtructions are often removed, and diſeaſes ſometimes cured, by electric ſparks and electric ſhocks; in giving which the following rules ſhould be obſerved. The ſhocks ſhould be very ſmall at firſt, and ſhould never be ſo great as to give terror to the patient. In moſt caſes they ſhould be gentle and frequent. They ſhould be given to palſied limbs without paſſing thro the vitals; and, when this rule is obſerved, they may be greatly increaſed. They ſhould be continued for a long time, and ſhould be accompanied with proper medicines.

PROP. IV.

By great electric ſhocks, vegetables may be blighted, or killed; and animals may be ſtruck blind, or diſabled in their limbs, or inſtantly deprived of life.

SECT. XVII.

OF ELECTRIC METEORS.

PROP. I.

Lightning ſometimes moves in ſtraight lines, and ſometimes in angular directions. Its colour is ſometimes white, and ſometimes red. It is conducted by metals, water, &c. and is not conducted by glaſs, wax, &c. It ſcorches ſome bodies, burns others, and fuſes metals. It diſſipates or ſtrips off gilding without hurting the paper or painted wainſcot, to which it is fixed. It makes holes in ſome bodies, and rends or diſſipates others. It gives polarity to iron, reverſes the poles of magnetic needles, or deſtroys the magnetic power entirely. It blights and kills vegetables, ſtrikes animals blind, diſables their limbs, or deprives them of life in a moment; bringing on a ſpeedy putrefaction. It ſtrikes the higheſt and moſt pointed bodies; and is often accompanied with the noiſe called Thunder.

PROP. II.

Electric matter moves in the ſame manner, according as it goes thro a ſhort ſpace, or among bodies irregularly diſpoſed, or thro a conſiderable maſs of air; and its colour is like that of lightning.

PROP. III.

Lightning and electric matter are conducted and not conducted by the ſame kinds of bodies, ſee Sect. IV; and they inflame the ſame kinds of bodies, and fuſe metals, ſee Sect. II.

PROP. IV.

By a ſhock of electric matter gold-leaf may be diſſipated, or fuſed, without burning the paper, or painted boards with which it is in contact. Holes may be ſtruck thro bodies; wood may be ſhivered; glaſs may be broken; water, ſtone, lime, &c. may be diſſipated; earth may be torn up; gun-powder fired, &c.

PROP. V.

That the effects of electric matter upon iron, magnets, and vegetables, are the ſame as the effects of lightning upon them, appears from Sect. XV and XVI.

PROP. VI.

Animals may be ſtruck blind by an electric ſhock, or diſabled in their limbs, or killed inſtantly; and the putrefaction of animal bodies is haſtened by great ſhocks of electric matter.

PROP. VII.

Electric matter ſtrikes the higheſt, or moſt advanced, and the moſt pointed bodies; and it makes a noiſe as loud as thunder, in proportion to its quantity, and the maſs of air which it agitates.

PROP. VIII.

If a wire or rod of metal with a ſharp point is ſupported by non-conductors, and raiſed higher than the neighbouring hills, trees, or edifices, it will be electrified by the thunder-clouds which come near it. The Leyden phial may be charged, and every electrical experiment may be performed by it, in the ſame manner as with common electric matter.

A boy's kite or dragon, with a long wire, may be made to anſwer the ſame purpoſe.

PROP. IX.

A pointed pyramidical rod of metal erected on buildings, and communicating thro non-conductors, or leſs perfect conductors, with the moiſt earth, will either prevent a ſtroke of lightning altogether, or conduct it into the earth, ſo as that the building will receive no harm. A rod of metal may be fitted up in ſhips, which, in the ſame manner, will prevent their being hurt by lightning.

Cautions to be obſerved in raiſing kites, and thunder-rods, for experiments, or the ſecurity of houſes.

Of the ſecureſt places in the fields, and in houſes, againſt the deſtructive effects of lightning.

PROP. X.

Some electric matter may be drawn almoſt always from the air by a boy's kite, if the wire is long: and the clouds ſeem to be often plus or minus with regard to the trees, houſes, or hills to which they give lightning, or from which they receive it.

PROP. XI.

The prodigies that have been ſeen on the ſpears and helmets of ſoldiers, the commozants on the maſts of ſhips, and the lambent fires on the tops of ſteeples, ſeem to have been produced by ſmall quantities of lightning; and they may be imitated by electric matter.

PROP. XII.

If electric matter and inflammable air are thrown upon moiſt earth, over which a gentle wind paſſes, the appearances will be the ſame with thoſe of the ignis fatuus.

PROP. XIII.

If electric matter is made to paſs thro a very rare atmoſphere, it will dart from place to place with the appearances of the aurora borealis and auſtralis, commonly called ſky-ſtreamers; and it will reſemble what is called a ſhot or fallen ſtar, if ſome moiſture or inflammable air is interſperſed.

PROP. XIV.

During a bright and ſtrong aurora borealis in high latitudes, a noiſe is heard, and the magnetic needle rambles from its uſual poſition. A ſimilar noiſe, in a ſmall degree, may be produced by the ruſhing of electric matter: and a ſimilar rambling may be given by electric matter to a magnetic needle; and to a needle of the ſame conſtruction that is not magnetical.

Of great balls of fire which are ſometimes ſeen in the atmoſphere.

SECT. XVIII.

THEORIES IN ELECTRICITY.

Of the different theories in electricity. A review of the experiments which prove the above propoſitions, together with others upon which a theory of the electrical phenomena is founded.

MAGNETISM.

SECT. I.

OF MAGNETS, AND THEIR ATTRACTIVE QUALITY.

PROP. I.

Magnets attract iron, and no other body or bodies whatever, unleſs they have a mixture of iron.

PROP. II.

The action and re-action of the magnet and iron are mutual and equal.

PROP. III.

There are two parts in a magnet called its ſouth and north poles, which attract with greater force than its other parts.

PROP. IV.

If two magnets are brought near each other, and have a free motion, they will mutually attract each other, when their poles are of a contrary denomination. But if their magnetic powers are very unequal, and if they are brought very near each other, they will attract, tho of the ſame denomination.

PROP. V.

The attractive power of the magnet ſeems to decreaſe as the ſquares of the diſtances increaſe; but this law is ſubject to great variations from different cauſes.

PROP. VI.

The attraction of the magnet is not hindered nor increaſed by the interpoſition of any body whatever; excepting ſuch as are magnetical, or ſuch as are capable of being made ſo.

SECT. II.

OF THE REPULSIVE POWER OF MAGNETS.

PROP. I.

If two magnets are brought near each other, and have a free motion, they will mutually repel each other, when their poles are of the ſame denomination. But they will attract, if their magnetic powers are very unequal, and if they are brought very near each other.

PROP. II.

The repulſive power of the magnet is ſubject to the ſame law with the attractive; and is equally unaffected by the interpoſition of every body. Sect. I. Prop. V. VI.

SECT. III.

OF THE COMMUNICATIVE POWER OF THE MAGNET.

PROP. I.

The magnet will communicate all its properties, without any diminution of its own virtue, to a ſmall piece of iron that is rubbed upon its poles, or that is brought near them.

PROP. II.

Iron acquires and loſes the magnetic virtue much ſooner than ſteel.

SECT. IV.

OF THE DIRECTIVE POWER OF THE MAGNET.

PROP. I.

If a magnet has a free motion, one of its poles will always turn towards the north, and the other towards the ſouth.

PROP. II.

If the magnetic virtue is communicated to a ſmall piece of iron, that is floated on water, or hung by a thread, or ſuſpended on a prop, it will have a directive power like a magnet; and it is called a magnetic needle.

Cor. From the above properties of the magnet, it is eaſy to underſtand many tricks, or contrivances, which excite wonder.

SECT. V.

OF THE MAGNETIC COMPASS.

Of the various ways in which the magnetic compaſs was formerly made for ſea and land.

Of the points of the compaſs or rhumbs.

Of the common mariner's compaſs, its conſtruction and uſe.

Of the beſt ſhape of the needle for the mariner's compaſs; beſt cap, prop, caſe, and manner of fitting it up.

SECT. VI.

OF THE DECLINATION OF THE NEEDLE.

PROP. I.

The declination or variation of the magnetic needle at a medium, was at Paris, A. D. 1541, 7° Eaſt. A. D. 1550, 8°, 0′, E. A. D. 1580, 11°, 30′ E. A. D. 1610, 8°, 0′ E. A. D. 1640, 3°, 0′ E. A. D. 1664, 0°, 40′ E. A. D. 1666, 0°, 0′. A.D. 1670, 1°, 30′ Weſt. A.D. 1680, 2°, 40′ W. A. D. 1686, 4°, 30′ W. A. D. 1692, 5°, 50′ W. A. D. 1700, 8°, 12′ W. A. D. 1710, 10°, 50′ W. A. D. 1720, 13°, 0′ W. A. D. 1726, 13°, 45′ W. A. D. 1728, 14°, 0′ W.; from which, to A. D. 1771, it moved to 19°, 45′ W.; and from A. D. 1771, at a ſlower rate weſt; ſo that, A. D. 1776, it had the appearance, it is ſaid, of being ſtationary.

The latitude of the obſervatory at Greenwich, near London, is 51°, 28′, 40″ N. and the longitude, 0°, 0′, 0″. The lat. of the obſervatory near Paris is 48°, 50′ 14″ N. and the long. 2°, 20′ 0″ E. The latitude of the obſervatory near Glaſgow is 55°, 51′, 36″ N. and the long. 4°, 24′, 0″ W.

PROP. II.

The mean variation at London, A. D. 1576, was 11°, 15′ eaſt. A. D. 1612, 6°, 10′ E. A. D. 1622, 6°, 0′ E. A. D. 1634, 4°, 5′ E. A. D. 1657, 0°, 0′.

A. D. 1665, 1°, 22′ weſt. A. D. 1672, 2°, 30′ W. A. D. 1683, 4°, 30′ W. A. D. 1692, 6°, 0′. W. A. D. 1700, 8°, 0′ W. A. D. 1730, 10°, 15′ W. A. D. 1744, 14°, 15′ W. A. D. 1756, 15′, 15′ W. A. D. 1759, 17° W. &c.

The mean of the annual variation for ſeveral years paſt in London has been about 10′ W.; but A. D. 1774, it was 21°, 16′ W. A.D. 1775, 21°, 43′ W.; and A. D. 1776, 21°, 47′. W.

PROP. III.

The mean variation at Glaſgow, A. D. 1775, was 24°, 21′ W. and, A. D. 1776, 24°, 30′ W. At Stromneſs, A. D. 1774, lat. 58°, 59′ N. and long. 3°, 30′ W. it was, by the azimuth compaſs, 24° W. In Hudſon's Straits, A. D. 1774, lat. 62°, 3′ N. and long. 69° W. it was 43° W. A.D. 1774, lat. 62°, 25′ N. and long. 71°, 30′ W. it was 44° W. A. D. 1773, lat. 79°, 50′ N. and long. 10°, 2′, 30″ E. it was 20°, 38′ W. A. D. 1774, lat. 56°, 53′ N. and long. 85°, 22′ W. it was 24° W. A. D. 1774, lat. 51°, 20′ N. and long. 82°, 30′ W. it was 17° W.

PROP. IV.

Near the equator, in long. 40° Eaſt, the higheſt variation from A. D. 1700, to A. D. 1756, was 17°, 15′ Weſt; and the leaſt 16°, 30′ W. In lat. 15° N. and long. 60° W. the variation was conſtantly 5° E. In lat. 10° South, and long. 60° E. the variation decreaſed from 17° W. to 7°, 15′ W. In lat. 10° S. and long. 5° W. it increaſed from 2°, 15′, to 12°, 45′ W. In lat. 15° N. and long. 20° W. it increaſed from 1° W. to 9° W. In the Indian ſeas the irregularities were greater, for A. D. 1700, the weſt variations ſeem to have decreaſed regularly from long. 50° E. to long. 100° E.: but A. D. 1756, the variation decreaſed ſo faſt, that there was eaſt variation in long. 80°, 85° and 90° E.; and yet, in long. 95°, and 100° E. there was weſt variation.

PROP. V.

A.D. 1772, in lat. 20°, 28′ South and long. 22°, 7′ W. the variation was 3°, 16′ W. In lat. 25°, 12′ S. and long. 23°, 31′ W. it was 1°, 11′ W. In lat. 40°, 20′ S. and long. 16°, 27′ W. it was 19°, 55′ weſt.

A. D. 1773, in lat. 61°, 9′ S. and long. 31°, 42′ E. it was 28°, 19′ W. In lat. 60°, 58′ S. and long. 97°, 26′ E. it was 40°, 31′ W. In lat. 56°, 5′ S. and long. 150°, 10′ E. it was 13°, 4′, 30″ W. In lat. 46°, 23′ 30″ S. and long. 163° 55′ E. it was 12°, 7′ E. In lat. 20°, 58′ 30″ S. and long. 192°, 5′ E. it was 9°, 44′ E. In lat. 51°, 40′ S. and long. 225°, 6′ E, it was 7°, 7′, 30″ E. In lat. 56°, 57′, S. and long. 240, 47′ E. it was 90°, 23′, 30″ E. In lat. 70°, 20′ S. and long. 253°, 3′ E. it was 24°, 46′ E.

A. D. 1774, in lat. 15°, 6′ S and long. 241°, 0° E it was 2°, 31′, 30″ E. In lat. 10°, 30′ S. and long. 220°, 8′ E. it was 5°, 28′ 30″ E. In lat.

20°, 1′, 30″ S. and long. 184°, 40′ E. it was 11°, 8′, 15″ E. In lat. 20°, 52′ S. and long. 166°, 8′ E. it was 10°, 12′ E.

A. D. 1775, in lat. 58°, 17′ S. and long 348°, 16′ E, it was 0°, 16′ W. In lat. 2°, 24′ N. and long. 32°, 12′ W. it was 0°, 14′, 45″ W. In lat. 50°, 6′, 30″ N. and long. 4°, 0′ W. it was 19°, 28′ W.

Of the variations collected by Halley; and by Dodſon and Mountaine: and of variation-charts and books.

Of the variation compaſs; and the beſt manner of fitting it up.

Of the azimuth compaſs, and its uſe.

Of the importance to philoſophy and navigation, of obſerving the variations in different parts of the earth.

SECT. VII.

OF THE INCLINATION OF THE MAGNETIC NEEDLE.

PROP. I.

The inclination or the dip of the magnetic needle at London, A. D. 1576, was 71°, 50′. A. D. 1653, 72°, 45′. A. D. 1676, 73°, 30′. A. D. 1720, 75°, 10′. A. D. 1723, about 75°, &c.

PROP. II.

The inclination is different in the ſame latitude and longitude, according to the length of the needle, its weight, its magnetic power, and the manner in which it is ſuſpended.

Cor. Hence, tho there are tables of the inclination of the needle in a great variety of latitudes and longitudes, yet they are of little value; becauſe no accurate account is given of the needles that were uſed. The obſervers of late years, however, have ſtudied to remedy this imperfection.

Of the beſt method of conſtructing the dipping needle, and of making obſervations with it.

PROP. III.

The mean dip of the needle at London, A. D. 1775, was 72°, 30′; and A. D. 1776, the ſame. At Glaſgow, A. D. 1775, 75°, 30′; and, A. D. 1776, the ſame. At Stromneſs, A. D. 1774, 75°, 45′; and in Hudſon's Straits, 82°, 40′.

A. D. 1773, in lat. 52°, 17′ N. and long. 1°, 45′, 15″ E. it was 73°, 22′. In lat. 60°, 17′ N. and long. 2°, 42′ 30″ E. it was 73°, 30′. In lat. 70°, 45′ N. and long. about 0°, 22′, 0″ E. it was 77°, 52′. In lat. 74°, 5′ N. and long. 9°, 43′ E. it was 79°, 30′. In lat. 77°, 59′ N. and long. 11°, 4′, 30″ E. it was 80°, 26′. In lat. 78°, 36′ N. and long. about 10°, 17′, 30″ E. it was 80°, 45′. In lat. 80°, 29′ N. and long. about 11° E. it was 81°, 52″.

A. D. 1775, the dip at Albany Fort, lat. 52°, 24′ N. and long. 83°, 30′ W. was 79°, 17′, 7″. In lat. 56°, 53′ N. and long. 85°, 22′ W. it was 82°, 25′.

PROP. IV.

A. D. 1775, in lat. 15°, 55′ South, and long. 5°, 49′ W. the mean of the dip was 11°, 20′ 45″.

A. D. 1773, in lat. 38°, 21′, 30″ S. and long. 178°, 83′, 45″ E. it was 62°, 25′ 40″. In lat. 45°, 47′, 56″ S. and long. 166°, 2′, 46″ E. it was 70°, 4′, 5″.

A. D. 1774, in lat. 55°, 21′ 57″ S. and long. 289°, 57′, 9″ E. it was 66°, 5′, 2″.

Of the uſe of the dipping needle in philoſophy and navigation.

SECT. VIII.

OF THE DAILY VARIATION OF THE MAGNETIC NEEDLE.

PROP. I.

From about eight or nine o'clock in the morning, every day, a good variation needle moves weſtward till about two or three o'clock afternoon; when it becomes ſtationary for ſome time; after which it gradually comes back to its former ſituation, or near it, by the next morning.

PROP. II.

This daily variation, which is commonly from 6′ to 14′, is greater in ſummer than in winter; and it is moſt remarkable in ſudden changes of the temperature of the weather, or of the place where the needle is kept.

PROP. III.

There is a daily variation in a fine dipping needle, which is ſimilar to that of the horizontal needle; but the daily variation of the firſt ſeems not to be ſo great as that of the ſecond.

SECT. IX.

OF DIMINISHING AND IMPROVING THE VIRTUE OF MAGNETS.

PROP. I.

A magnet is diminiſhed in power by not being kept, or depoſited, in ſuch a manner as that its poles are in the magnetic line, or line of variation; the pole commonly called the north pole being placed towards the north pole of the earth in the northern hemiſphere; and the pole commonly called the ſouth pole being placed towards the ſouth pole of the earth in the ſouthern hemiſphere.

Of the contrary manner of naming the poles of a magnet, in conſequence of the earth's being conſidered as a great magnet.

PROP. II.

A magnet will become weak, if a piece of iron is not kept in contact with, or near to, its poles.

PROP. III.

Tho the power of a magnet is not diminiſhed by communicating its virtue to a ſmall piece of iron; yet it may be diminiſhed greatly by communicating its virtue to a piece of iron that is large, compared to the ſize or ſtrength of the magnet.

PROP. IV.

Heat diminiſhes the ſtrength of a magnet; and if it is much heated in the fire, it will loſe its virtue altogether.

PROP. V.

A ſmart blow will ſometimes change the poles of a magnet, and ſometimes deſtroy the magnetic power entirely.

PROP. VI.

By placing magnets near each other their virtue is often impared. But by a certain poſition of a ſmall magnet near great ones, its virtue may be improved. Sect. x. Prop. IV.

PROP. VII.

A natural magnet is ſometimes ſo formed, that it may be cut with a ſaw in ſuch a manner as that two or more magnets may be made out of it; and one or two of them may have a ſtronger virtue than the ſingle ſtone had before it was cut.

PROP. VIII.

By armour a magnet is made fitter for experiments and uſe; and as the armour collects the magnetic power into ſmaller bounds, the magnet will, by means of it, give a ſtronger touch, and ſuſtain a greater weight.

SECT. X.

OF CHANGING THE POLES OF MAGNETS.

PROP. I.

If a ſmall flat magnet B, having its poles at each end, is placed lengthways between two larger magnets C and D, the ſouth poles of which are oppoſed to each other; and if the north poles of two ſmaller magnets E and F are applied to the middle of B, then both the ends of B will have ſouth poles, and its middle will be one continued north pole.

PROP. II.

The oppoſite ends of the magnet B, which are now ſouth poles, may be made both north poles; and the two ſides ſouth poles, by an operation ſimilar to the laſt.

PROP. III.

If B is placed ſo as that the oppoſite halves of its two flat ſurfaces are in contact with the contrary poles of C and D when placed in the ſame ſtraight line; and if after remaining ſo for ſome time, the other oppoſite halves are placed in the ſame manner, but in a contrary direction, then the one half of the ſurfaces of B will be a north pole, and the other half a ſouth pole; ſo that the north pole of the one ſurface will be oppoſite to the ſouth pole of the other.

PROP. IV.

If B is placed between C and D, ſo as to give it a ſtrong and regular polarity at the two ends; and if its whole ſurface, except the poles, is touched with the pole of D or of E, but in a direction quite contrary to the firſt polarity; then the north pole of B will be ſurrounded with a ſouth pole, and its ſouth pole will be ſurrounded with a north pole; ſo that the edges of each ſurface will have a pole of a different denomination from that which occupies the middle.

SECT. XI.

OF ARTIFICIAL MAGNETS.

PROP. I.

A bar of iron will acquire the properties of the magnet by placing it for ſome time in a ſituation perpendicular to the ſurface of the earth; and in northern countries the end next the earth is the north pole.

PROP. II.

The magnetic power may be given to a piece of iron by hammering it when cold in the magnetic line; or by plunging it in water, when red hot, in the ſame, or in a vertical poſition.

PROP. III.

By rubbing pieces of iron againſt each other they become magnetical; or by breaking a piece of iron by bending it often in different directions.

PROP. IV.

If ſeveral plates of ſteel are touched by a ſtrong magnet, if they are put together, ſouth pole to ſouth pole, with iron interpoſed, and properly armed, they will make a good artificial magnet.

PROP. V.

Artificial magnets made according to the methods of Mr. Savary, Dr. Knight, Mr. Michel, and Mr. Canton.

PROP. VI.

By theſe methods magnets may be made at a ſmall expence, which are much ſuperior to any that are natural.

SECT. XII.

OF THE IMMEDIATE CAUSE OF THE MAGNETIC VIRTUE.

PROP. I.

The magnetic power or virtue ſeems to move in a ſtream from one pole of a magnet to the other internally; and to be then carried back in curve lines externally, till it arrives at the pole to be again admitted.

PROP. II.

The immediate cauſe why two or more magnetical bodies attract each other, ſeems to be the flux of the ſame ſtream of magnetic matter thro them.

PROP. III.

The immediate cauſe of magnetic repulſion ſeems to be the conflux and accumulation of the magnetic matter.

SECT. XIII.

THEORIES IN MAGNETISM.

Of the hypotheſes which have been formed in order to explain the phenomena of the magnet.

A theory of its attractive, repulſive, communicative, and directive power; of the declination, and inclination of the needle, diurnal and annual; of artificial magnets; and of the other magnetical phenomena.

GRAVITATION.

SECT. I.

OF GRAVITY UPON, OR NEAR, THE SURFACE OF THE EARTH.

PROP. I.

The power of gravity produces motion in bodies in the direction which the perſon who makes the experiment calls downwards; or, when that motion is reſiſted, the preſſure called weight: and all bodies, whether called heavy or light, or hard or ſoft, are ſubject to this power; and at all times.

PROP. II.

The motion and preſſure of bodies, acted upon by gravity alone, is in lines perpendicular to the horizon.

Cor. Hence the uſe of the plummet in drawing lines perpendicular, or parallel, to the horizon.

Tho ſuch perpendiculars are not exactly parallel, ſee Prop. VII. yet if drawn in a great plane, and near the ſame place, the errors are ſo ſmall, that no human art can meaſure them.

PROP. III.

The motion of falling bodies is equally ſwift, whatever be their forms or their quantities of matter; provided they fall from the ſame height, and meet with no reſiſtance.

Cor. 1. The weight of bodies is according to their quantities of matter; and not according to their texture, forms, or bulks.

Cor. 2. The preſſure of bodies is according to the ſame law; but the effects of preſſure upon the reſiſting body may be different, according to the baſes of the preſſing bodies, or the texture of the reſiſting body.

PROP. IV.

When bodies fall thro the ſame reſiſting medium, their retardations are proportional to their quantities of matter, all other circumſtances being equal.

PROP. V.

The motion of all bodies which deſcend by gravity, is a motion equably accelerated.

Cor. 1. Bodies thrown upwards loſe equal velocities in equal times.

Cor. 2. Whatever velocity a falling body acquires in a given time; if it is thrown perpendicularly upwards with the ſame velocity, it will loſe as much in an equal time.

Cor. 3. If a body is thrown upwards with the velocity acquired by falling in a given time, it will in the ſame time loſe all its motion.

PROP. VI.

In Britain a ball of metal falls about one Engliſh foot, in the fourth part of one ſecond of time; about four feet, in half a ſecond of time; ſixteen feet and one twelfth part, in one ſecond of time; and about ſixty-four feet in two ſeconds of time.

Cor. 1. Hence the ſpaces paſſed over by bodies moving by gravity are as the ſquares of the times of their falling from reſt; and if the times of falling were increaſed, the ſpaces paſſed over would be as follows.

Seconds of time.	Feet in any ſecond.	Feet in the whole fall.
1	1	16
2	3	64
3	5	144
4	7	256
5	9	400
6	11	576
7	13	784
8	15	1024
9	17	1296
10	19	1600
15	29	3600
20	39	6400
25	49	10000
30	59	14400
35	69	19600
40	79	25600
45	89	32400
50	99	40000
55	109	48400
60	119	57600

Cor. 2. Taking equal parts of time, the ſpaces deſcribed by a falling body in each ſucceſſive part

of time, will be as the uneven numbers 1, 3, 5, 7, 9, 11, &c.

Cor. 3. A body moving uniformly with the velocity acquired by falling thro any ſpace, will deſcribe twice that ſpace in the time of its fall.

Cor. 4. If bodies are thrown perpendicularly upwards, the heights of their aſcent will be as the ſquares of their firſt velocities, or as the ſquares of the times of their aſcending.

Cor. 5. If a body is thrown perpendicularly upwards with any velocity; with the ſame velocity undiminiſhed, it will deſcribe twice the ſpace of its whole aſcent in the ſame time.

PROP. VII.

The figure of the earth is proved to be globular by the following phenomena. The riſing and ſetting of the ſtars is accelerated to a traveller who goes eaſt, and retarded to one who goes weſt: but if he goes from ſouth to north, the north pole is elevated one degree for about every ſixty-nine miles and an half; and the contrary when he goes ſouth. When the ſhadow of the earth falls upon the moon, it is always circular. To the people in a ſhip which approaches a tall object, the higher parts of it come firſt in view; and, when ſhe recedes from it, the lower parts are the firſt that diſappear. A ſhip which continues to ſail in one direction ſurrounds the earth. If a ſhip ſurrounds it by going eaſt, while another ſurrounds it by going weſt; when they meet, there will be a difference of one day in the computation of time by the people in the two ſhips. Perpendiculars to the horizon made by plummets, at conſiderable diſtances from each other, are found not to be parallel, but to tend towards a center.

Cor. Since the length of 1°, or one part of 360°, meaſured upon the ſurface of the earth is ſixty-nine Engliſh miles and an half; the circumference of the earth, if a true globe, is 25,020 miles; and its diameter, 8,000 miles, in round numbers: or, more accurately, if the length of one degree on the ſurface of the earth is 25 French leagues, its whole circumference, if a true globe, is 9,000 leagues; each league containing 2,283 French fathoms; 830 of which make an Engliſh mile, or 5,280 ſtatute feet.

PROP. VIII.

The power of gravity is different in different latitudes; and, by calculations founded on experiments is, in proportional numbers, as follows.

Gravity.	Lat. North.		Places.
100000	48°,	50′	Paris.
100018	51,	28	London.
100126	64,	35	Archangel.
100137	66,	48	Pello.
99929	41,	44	Rome.
99925	30,	2	Cairo.
99732	18,	27	St. Domingo.
99744	18,	0	Jamaica.
99533	14,	44	Martinico.
99533	4,	56	Cayenne.

Gravity.	Lat. South.	Places.
99631	0°, 2′	P. Palmar.
99605	0, 9	Rhiobambe.
99802	0, 14	S. Sea coaſt.
99643	0, 25	Quito.
99906	16, 0	St. Helena.
100036	34, 24	C. Good Hope.

See Mechanics, Part VI. Sect. IV. and V.

PROP. IX.

It was found by meaſuring a degree of the earth at different latitudes, that the earth is an oblate ſpheroid; the axis being to the diameter of the equator as 229 to 230; that is, the ſemi-axis being about ſeventeen miles leſs than the ſemi-diameter of the equator.

Of the manner of making this calculation; and of other proportions by different calculations.

Scholium. If one diameter of the earth is 6′,562,024 fathoms, or 2,874 leagues and three fourths; and if the other diameter is 6′,525,376 fathoms, or 2,858 leagues and two fifths; then the whole bulk of the earth is 12,366′,044,000 cubic leagues; its whole ſurface, 25′,858,089 ſquare leagues: and, if we ſuppoſe its mean denſity to be equal to that of common clay, a cubic foot of which weighs about 140 ℔, then the weight of a cubic fathom is 30,240 ℔; the weight of a cubic league, 359″,775,200′,000,000 ℔; and the weight of the whole terraqueous globe, 4⁗,448,994‴,000,000″,000,000′,000,000 ℔.

PROP. X.

By experiments made at the level of the ſea, and at different altitudes from it upon the immenſe mountains in South America, it was proved that the power of gravity decreaſes as we recede from the center of the earth, and nearly in the inverſe duplicate ratio of the diſtances.

Cor. 1. The difference of the power of gravity at ſmall diſtances from the level of the ſea cannot be perceived by the moſt acute ſenſe, or accurate inſtrument. For if the radius of the earth is 4000 miles; at the top of a mountain, one mile in perpendicular height, the diſtance from the center of the earth will be 4001 miles; and, therefore, the power of gravity at theſe diſtances will be as 16,000,000 to 16,008,001; or, as 16,000 to 16,008.

Cor. 2. If a body on the ſurface of the earth, or at one ſemi-diameter from the center, weighs 3,600 ℔, it will, at the diſtance of 2, 3, 4, 5, 6 ſemidiameters, weigh 900, 400, 225, 145, 100 ℔.

PROP. XI.

By the attraction of the mountain Chimboraço in Peru, a plummet was drawn from the true vertical line ſo as to make an angle with it of eight ſeconds. This mountain is about two miles in height above the level of the province of Quito; and 3217 fathoms, or about 20,280 feet, or near four miles, in perpendicular height above the level of the ſea. Tho it is the largeſt mountain in the earth, yet it is about 7,400',000,000 of times leſs in bulk than the earth; and its attraction upon the plummet, if it is ſolid, ought to have been thirteen times greater than 8″; but it is hollowed by ſubterraneous fires, which produce frequent volcanos; and which, perhaps, have made the whole mountain.

The mean effect of the attraction of the mountain Shehallien in Perthſhire, is 5″, 8‴; and from its magnitude compared to that of the whole earth, it appears that the mean denſity of the earth is about double that of the mountain. The direction of Shehallien in length is nearly eaſt and weſt; its height above the ſurrounding valley is, at a medium, about 2,000 feet; and its higheſt part above the level of the ſea is 3,550 feet.

PROP. XII.

The effect of the attraction of the moon, and of the ſun, upon large ſurfaces of water in the earth, is diſtinctly ſeen; but the effect of their attractions upon ſmall ſurfaces cannot be meaſured. See Part VII. Hydroſtatics, and Part X. Aſtronomy.

SECT. II.

OF GRAVITY IN THE HEAVENLY BODIES.

See Part X. Aſtronomy.

SECT. III.

THEORIES IN GRAVITATION.

Of the various hypotheſes which have been formed concerning the cauſes of gravity.

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Docenti cuique ſuo utendum judicio, ſua arridet methodus, docendi ratio, rerum ſeries, argumentorumque momenta, quae diſcentium ingeniis, ut juvenum captus eſt, optimè accomodata, atque ad ſenſus penitùs permanantia, ſibi videntur. Quumque noſtra methodus, iſtis quae nuper invaluerunt, non paullum diſcrepet; ſi quid ea afferat quod diſcipulis prodeſſe poteſt, eorum intererit, breve aliquod in manibus terere ſyntagma, quod rerum ſeriem, ſummaque diſputationum capita exhibeat; ipſiſque omnia vivâ voce fuſius explicata, in memoriam revocet.

F. HUTCHESON Inſt. Comp. Ph. Mor.

Σωμάτιον, ου, το. Corpuſculum. Apud Athen. lib. 4. lib. 13. ISOCR. in Epiſt. ad Phil. &c.

H. STEPH. Theſ.

Οἱ ἀπὸ Θάλεω, καὶ Πυθαγόρου, παθητὰ σώματα, καὶ τμητὰ εἰς ἄπειρον· ἢ τὰς ἀτόμους, ἢ τὰ ἀμερῆ, ἵστασθαι, καὶ μὴ εἰς ἄπειρον εἶναι τὴν τομήν.

PLUTAR. de Placit. Philoſ. lib. 1.

Ἀριστοτέλης δυνάμει μὲν εἰς ἄπειρον σώματα τμητὰ εἶναι, ἐντελεχείᾳ δὲ οὐδαμῶς.

Idem.

Σωκράτης, καὶ Πλάτων τὸ ἓν τὸ μονοφυὲς, καὶ αὐτοφυὲς, τὸ μοναδίκον, τὸ ὄντως ἀγαθόν. Πάντα δὲ ταυτᾶ τῶν ὀνομάτων εἰς τὸν νοῦν σπεύδει. Νοῦς οὖν ὁ θεός χωριστὸν εἶδος, τουτ᾽ ἐστι τὸ ἀμιγὲς πάσης ὕλης, μηδένι παθήτῳ συμπεπλεγμένον.

Idem.

BIBLIOTHECA BODLEIANA

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Off.

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